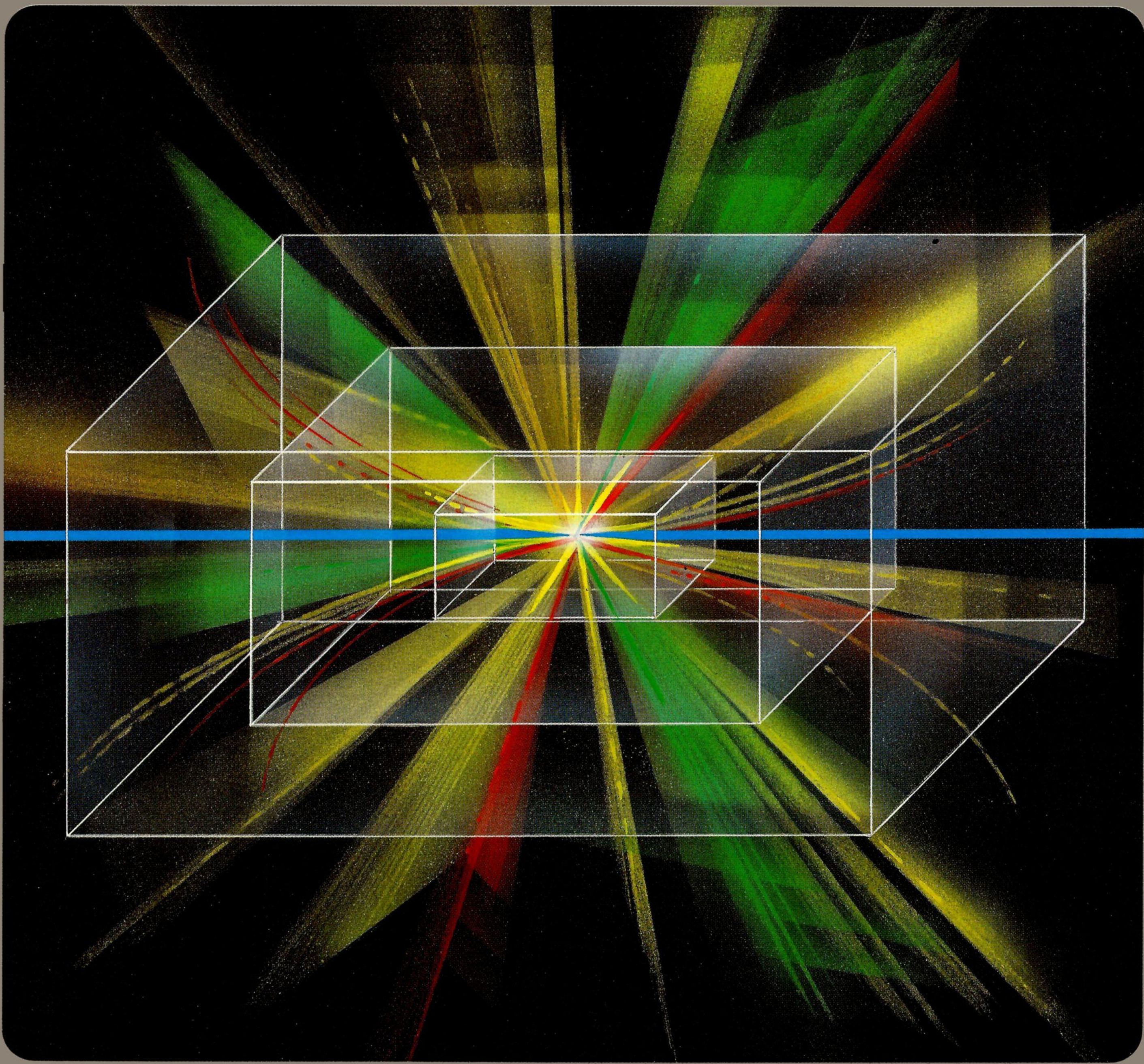
CERN COURIER

International Journal of High Energy Physics



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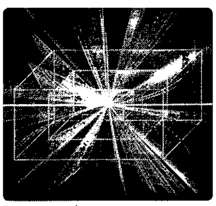
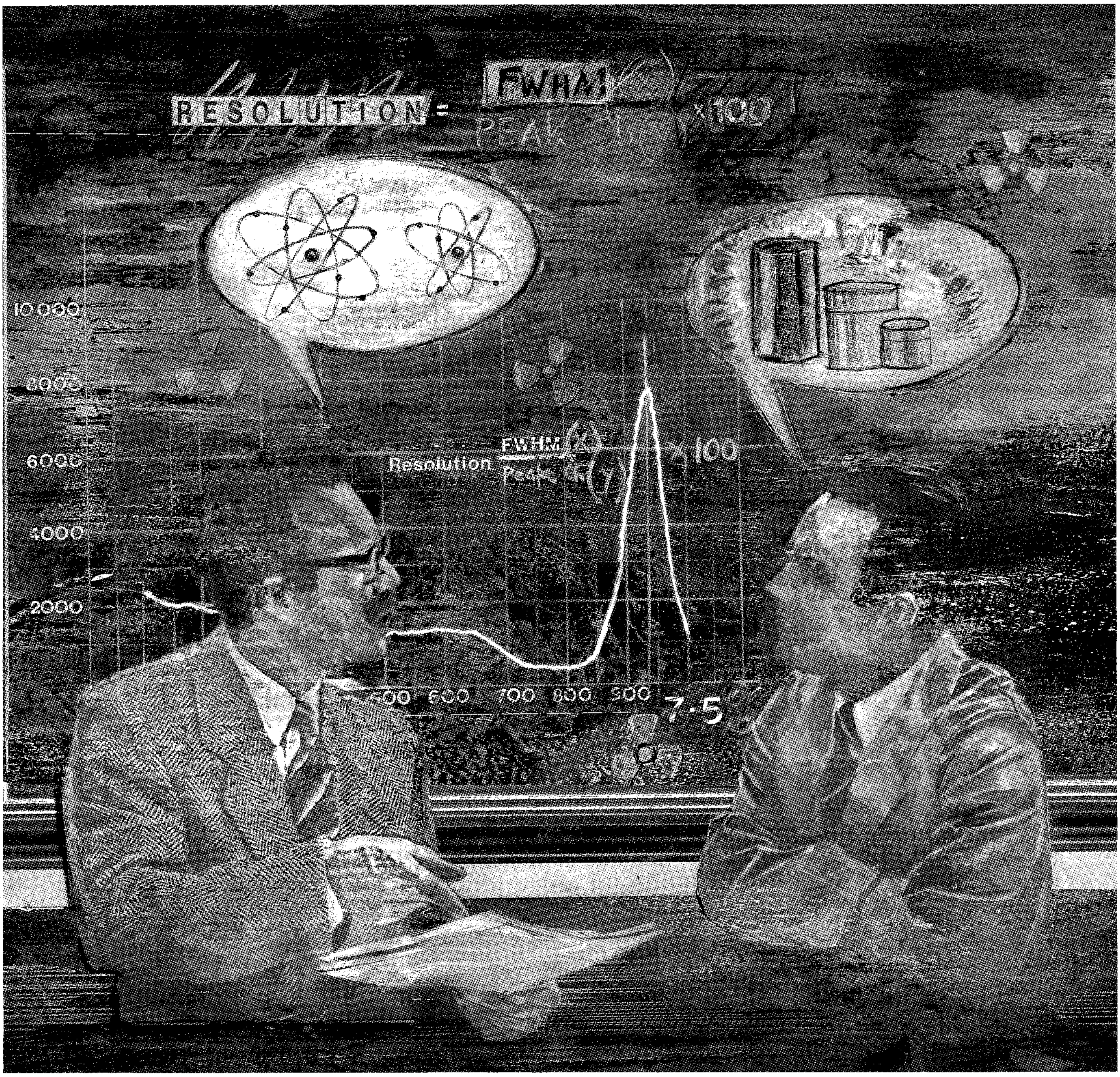


Cover photograph:
Artist's impression of a high energy proton-proton collision. The detectors to record these collisions are now being developed (see page 18).



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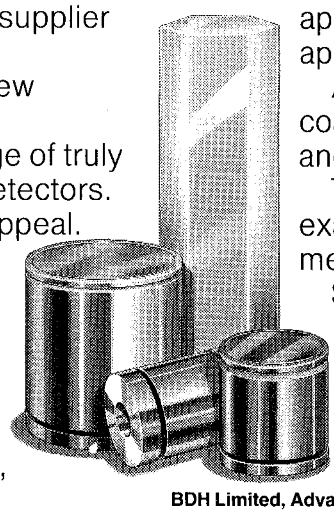

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Munich conference

Don Perkins – Standard Model, triumph or frustration?

'The Standard Model has survived intact for another year,' declared Don Perkins of Oxford, summarizing the 24th International Conference on High Energy Physics held in Munich from 4-10 August. 'But is this a triumph or a frustration for physics?' he added.

The twin pillars of the Standard Model, the electroweak unification of electromagnetism and the weak nuclear force, and the field theory (quantum chromodynamics) of the quark-gluon interactions responsible for the strong nuclear force , have not trembled since the electroweak unification went to the textbooks in 1983, but from time to time small cracks have appeared which might have gone on to shake the theory severely, if not undermine it.

Major conference summarizers have got used to singing the praises of the Standard Model, but this year at Munich even detailed examination failed to reveal any serious cracks, while looking deeper into physics even some anomalous results hinting at gaps in understanding have either gone away or have diminished credibility.

Neutrinos

Given the job of summarizing 'non-accelerator' experiments, Yoji Totsuka of Tokyo had to cover a lot of material presented in the earlier parallel sessions. The enigmatic neutrino has long been the joker in the particle physics pack, but the latest crop of neutrino results shows it to be, at least by its own standards, remarkably well behaved.

Measurements of the mass of the electron-type neutrino, the lightest, are coming in from Moscow, Zurich, Los Alamos, Munich, Tokyo and Beijing. While most studies prefer to quote limits (as high as 30 and as low as 18 electronvolts), the Moscow (Institute for Theoretical and Experimental Physics) group underlines its longstanding positive result (26+6-5 eV). Perkins was pessimistic about the chances of any such experiment being able to rule out a neutrino mass below 10 eV.

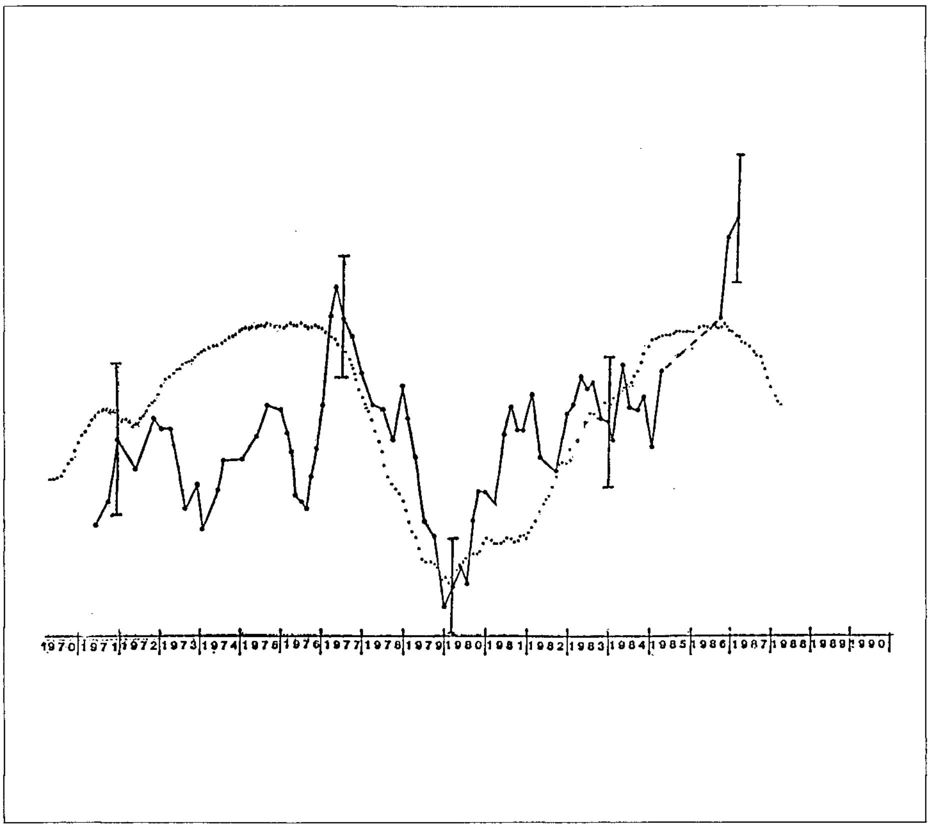
Other experiments show that the next neutrino, the muon-type, has to be lighter than about 285 keV, while the heaviest known neutrino, the tau, looks to weigh in at less than 35 MeV.

While the search goes on for double beta decay without any accompanying neutrinos, the past year has seen the sighting of a more conventional double beta decay (January/February issue, page 32). Elsewhere in the neutrino sector, evidence for 'oscillations' between different neutrino types has long been sought, using both terrestrial and extra terrestrial particles. At Munich, new evidence from the experiment at the French Bugey reactor now rules out oscillations, tying in with the negative results from other experiments at reactors and particle accelerators.

With extraterrestrial neutrinos, earlier this year the Japanese Kamioka experiment had announced a muon neutrino signal substantially less than expected (May issue, page 29), suggesting oscillation effects. However this is not confirmed by the Frejus experiment (France) or from preliminary results from the IMB (USA) study.

Covered by Totsuka in both the

Is there any longer a problem with solar neutrinos? For a long time, the only experiment monitoring neutrinos from the sun (led by R. Davis using a tank of chlorine-based absorber in a US mine) saw less particles than expected from confident estimates of solar neutrino activity. However a recent run (right) gives a sharply higher neutrino level, more in line with the predicted value. The dotted line shows sunspot activity – is the correlation superficial or is this a physics message?.



plenary and parallel sessions was the 'solar neutrino problem'. An underground experiment led by Ray Davis of Brookhaven for a long time reported that the level of neutrinos reaching a detector from the sun was only a fraction of what is expected. However in a recent run, the level has increased to be almost compatible with expectations. In parallel, independent solar neutrino results have started to come in from Kamioka, which, according to Totsuka, are 'compatible' with the more recent Davis findings. In the meantime, a big push continues to prepare new solar neutrino detectors (see for example May 1987 issue, page 26) and additional results in this sector are eagerly awaited.

Several speakers pointed to suggestions that the measured level of solar neutrinos could tie in with sunspot activity.

Participants at the conference had been intrigued by press reports of a new force (the so-called 'fifth force'), suggesting that the pull of gravity might depend on the composition of a body as well as its overall mass. Totsuka also echoed the sentiments of C. Stubbs of Washington, one of the experimenters in this area, who pointed out the difficulties in reconciling results from different, and frequently highly ingeneous, experiments, concluding that 'no reasonable phenomenological picture can account for all the data,' and that although there was 'no compelling evidence for new physics', there was still some room left to manoeuvre before a null result could be concluded.

Heavy quarks

The present picture of particle physics is based on three families of quark doublets – 'up' and 'down', 'strange' and 'charm', and 'beauty' (or 'bottom', b) and 'top' (t). All these quarks are known and now well studied, with the exception of top, but even here a series of limit have been charted fixing where it will turn up.

The most reliable limit comes from the level of hadronic (strongly interacting) particles seen in electron-positron annihilations. The world's highest energy fully operational electron-positron collider is TRISTAN at the Japanese KEK Laboratory. Here the collision energy has gradually been nudged upwards since the machine turned on in November 1986. At Munich, plenary speaker Tsuneyoshi Kamae of Tokyo showed how the hadron level shows no unexpected rise at the collision energies reached so far (up to about 28 GeV per beam), although the data points push tantalizingly close to the allowed limit if the top threshold has not been reached.

Another handle on top production comes from the detailed shape analysis of the 'jets' of produced hadrons, showing that TRISTAN is still in territory inhabited only by five sorts of quark. Next top limit (41 GeV) comes from the UA1 detector at CERN's proton-antiproton collider, followed by about 60 GeV from the observed 'mixing' of electrically neutral B mesons (containing b quarks). After an initial report on this mixing from UA1 in 1986, more information came last year from the ARGUS experiment using the DORIS ring at the German DESY Laboratory in Hamburg. The level of neutral B mixing looked to

At the opening of the plenary sessions of the International Conference on High Energy Physics in Munich on 8 August. Left to right, Organizing Committee Chairman G. Buschhorn, Bavarian State Government Minister for Science and Culture W. Wild, CERN Director General Herwig Schopper and CERN Council President J. Rembser.

(Photos Uni Munchen F.M. Schmidt)

be surprisingly large. At Munich, this result was confirmed by the CLEO group working at Cornell's CESR electron-positron collider. 'The mixing of the neutral B mesons is indeed huge,' commented Henning Schröder of DESY, in his report on the spectroscopy and decays of heavy quarks.

An upper limit for the mass of articles containing the top quark comes from comparison of Standard Model parameters coming from different approaches. The particles have to be lighter than about 250 GeV, and with some hopeful assumptions the limit can be clawed down to 180 GeV.

This means that top particles could be within reach of the proton-antiproton colliders at CERN and Fermilab. The latter has higher collision energy on its side (1800 GeV compared with CERN's routine 630 GeV), but CERN is pushing hard to boost the collision rate (luminosity). 'We could find top by next year, let alone the next Rochester Conference, commented Perkins.

The impressive results from proton-antiproton collision physics at CERN and Fermilab were summarized at Munich by Melvin Shochet of Chicago, staying close to the findings of the recent proton-antiproton physics workshop at Fermilab (September issue page 4).

Besides the top quark, the other missing ingredient of the Standard Model is the 'Higgs' mechanism responsible for the delicate symmetry breaking driving the electroweak unification. 'The Higgs is the most arbitrary part of the Model,' said Standard Model summarizer Paul Langacker of DESY. 'The only thing that can be said with complete certainty is that the mass of the Higgs particle, if it exists, must be between zero and infinity!' Undeterred, he looked at what a few assumptions could do for predictions in this sector.

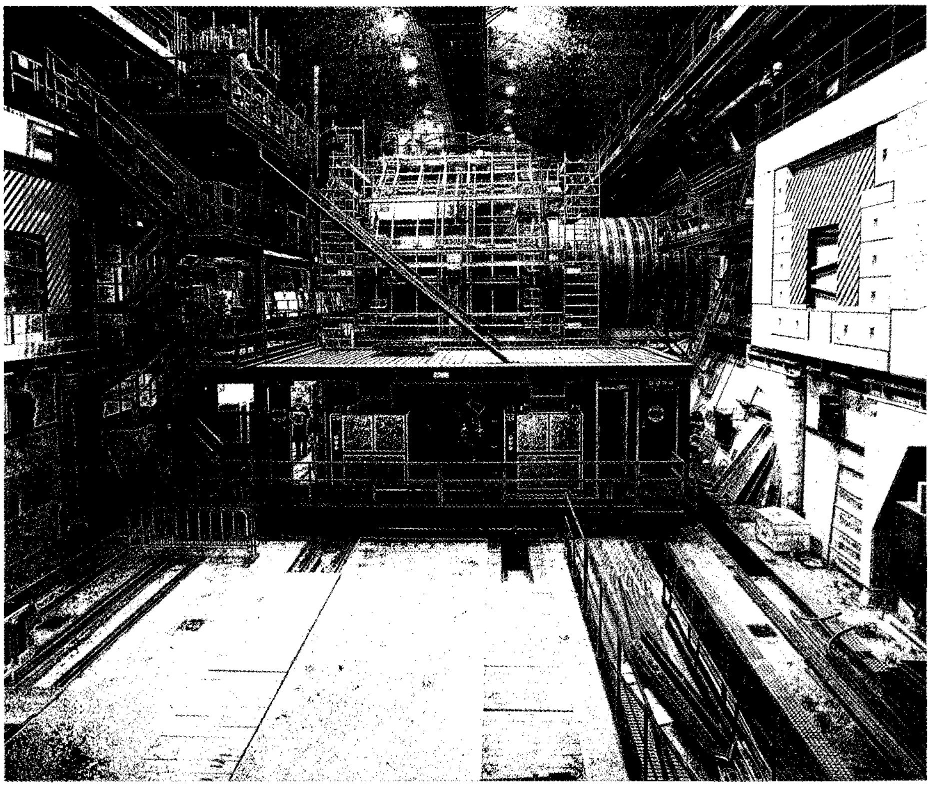
Putting undiscovered particles aside, Schröder underlined the importance of measurements on particles containing the b quark. Over twenty years ago, it was discovered that electrically neutral kaons have no respect for the classical invariance principle of particle/antiparticle permutation combined with left/right reversal. This 'CP violation' is still not understood, but can be accommodated into a six quark model. For this Cabibbo/Kobayashi/Maskawa scheme to be right, B particles (containing the b quark) should be able to decay into particles containing lighter quarks without passing through an intermediate stage involving charm quarks.

Last year, the ARGUS experiment reported such 'charmless' B decay, (September 1987, page 4) but the level of the signal surprised many specialists. After a further report from ARGUS in a Munich parallel session underlining their earlier findings, David Kreinick of Cornell described a 'diligent' search at the CLEO detector at CESR which failed to find any evidence for charmless B transitions – 'clear disagreement'. In his plenary talk, Schröder called for more data to resolve this 'discrepancy', looking particularly for simpler B decays more easily interpreted theoretically.

In his talk on CP violation and related matters, Konrad Kleinknecht of Mainz stressed the need to find charmless B decays, pointing out also that the long-awaited top quark should also decay predominantly into the b variety. He presented the latest CP violation results from the NA31 experiment at CERN (July/August issue, page 7). Earlier Hitoshi Yamamoto of Fermilab had sketched the Fermilab

At Munich, CERN Research Director John Thresher covered the impressive progress being made at CERN for the 27 kilometre LEP electron-positron collider and its four big experiments. Here the Aleph detector starts to take shape 150 metres below ground. In front and on either side of the assembly is the shielding where the LEP beams will enter the detector.

(Photo CERN 210.6.88)



E731 experiment also aiming for a precision fix on CP violation. After a substantial period of data-taking, initial results could emerge before the end of the year.

Plenary speaker Roland Windmolders of CERN, echoing what emerged from the parallel sessions, reported on the latest measurements from CERN, Fermilab and Stanford of the distributions of quarks and gluons inside nucleons (structure functions). While many results from different experiments appear to converge, certain structure functions measured at CERN using muon beams by the European Muon Collaboration (EMC) and the Bologna/CERN/Dubna/Munich/Saclay group do not agree. This makes problems for calculations using these structure functions as input. Ongoing studies at CERN and Fermilab could help resolve the problem, but Perkins remarked 'it is a shame that after ten years of work there are such clear discrepancies'.

Debuting at a big conference was the EMC measurement showing that between them the constituent quarks of the proton appear to carry almost none of the particle's intrinsic spin angular momentum (June issue, page 9).

Structure functions provide input to quark calculations, summarized by Keith Ellis of Fermilab. While bemoaning the disagreement between structure function measurements, Ellis was able to summarize 'a bumper year' of calculations which help to explain many of the details of particle production. One outstanding problem was to explain the EMC quark spin result.

Additional high energy input is coming in from the production of hadron jets at TRISTAN, throwing further light on the way produced quarks and gluons materialize as hadrons. Earlier Steve Olson of the AMY experiment at TRISTAN had drawn attention to 'dramatic' effects in the distribution of the leading particles in jets produced by gluons.

If enough energy is available, the quarks and gluons locked inside nucleons should eventually fuse into a quark-gluon plasma. Seeing hints of this plasma is one of the aims of the experiments at CERN and Brookhaven using high energy nuclear beams. Louis Kluberg of the Ecole Polytechnique, Paris, surveyed the results so far and the attempts to unravel possible quark-gluon plasma signals.

Machines

Introducing the Munich plenary sessions, CERN Council President J. Rembser sketched the world scenario of major machine projects, calling for a maximum of international collaboration. In special sessions, John Thresher of CERN described the impressive progress being made with the 27 kilometre LEP electron-positron collider, and its four big experiments, with a positron beam having been steered round the first completed octant of the ring (September issue, page 7). LEP is well on course for first colliding beams next summer.

After LEP, it was the turn of Bjorn Wiik of DESY to cover the status of the HERA electron-proton collider. Injection into the completed electron ring was imminent (see page 20), and the first octant of the 6.3 kilometre superconducting proton ring is scheduled for testing next spring en route to first colliding beams in October 1990.

Burt Richter of Stanford surveyed future colliders. Turning first to proton machines, Richter pointed out the progress being made at Serpukhov, USSR, for the UNK proton accelerator and collider, while the giant SSC Superconducting Supercollider in the US and the LHC scheme at CERN using the LEP tunnel were a step further in the future.

The published Munich schedule had included a slot for the new SLC Stanford Linear Collider now being commissioned. This slot was finally cancelled, but Richter claimed that as a 'proof of principle' the SLC had worked, although severe reliability problems in the veteran two-mile linac supplying the beams had prevented the SLC project from getting anywhere near its goal of manufacturing one Z particle (the carrier of the electrically neutral component of the weak nuclear force) per day.

Theory

With quark field theory calculations now a minor industry, Roberto Petronzio of Rome outlined the results coming in from lattice calculations using powerful computers. This work is beginning to provide important additional input, while encouraging initial progress is being made in analytical lattice approaches dispensing with the computers.

J. Frohlich of Zurich looked at the invasion of geometrical and topological ideas which aim at liberating field theory from the bondage of a series perturbation approach, not necessarily convergent. With superstrings being touted as the best bet for unified physics, David Gross of Princeton looked at the problems and the possibilities.

These unifications of the forces of physics look like happening only at extreme energies, and Andrei Linde of Moscow believed that the cosmological mechanics of the Universe provided the only hope for seeing these effects. Exploiting the effects of cosmological 'inflation', Linde had some bad news for the fate of the Universe ('Is Mankind doomed to die inside a black hole?'), but the timescale (about ten to the power a thousand times the present age of the Universe) gave no cause for immediate concern.

A bit closer to home, Lawrence Hall of Berkeley looked at physics 'just beyond' the Standard Model as experiments begin to attack the TeV (1000 GeV) region, where one hope is to finally see hints of the long-awaited Higgs sector.

With no physics coming in from the SLC Stanford Linear Collider, the slot originally allotted to SLC in the Munich programme was taken over by Yoshio Yamaguchi, Chairman of the International Committee for Future Accelerators (ICFA), who outlined ICFA's current commitments (see September issue, page 14).

Organizing jumbo-sized conferences demands hard work and meticulous attention to detail. Perkins echoed the sentiments of all the participants when he thanked the Munich organizers, particularly Gerd Buschhorn and Klaus Pretzl of Munich's Max Planck Institute for Physics and Astrophysics, respectively Chairman and Secretary of the Organizing Committee, for their imaginative and unstinting work in making the event a success.

With so many arbitrary parameters, the Standard Model cannot be the last word in physics. With evidence for a deeper level of understanding reluctant to show up from laboratory experiments, Perkins looked forward eagerly to the next supernova, in the year 2003 ± 15!.

By Gordon Fraser

The Munich conference attracted exhibitors from industry.

The Rochester tradition

In 1951, Robert Marshak got together about 50 visiting high energy physicists at Rochester University, New York, to discuss new results and ideas. No proceedings were published, but the Rochester idea was born, and subsequent annual meetings at Rochester went on to become a regular feature of the high energy physics calendar.

In 1957, the International Union of Pure and Applied Physics (IUPAP) set up a High Energy Physics Commission whose tasks included supervising the organization of this annual international conference whose venue would rotate between Europe, the USSR and the USA. Thus in 1958 the eighth conference in the series, the first away from its birthplace, was held at CERN. In 1959 physicists went to Kiev, and the following year returned to Rochester.

In these early years, the traditional Rochester pattern emerged of initial parallel sessions on specialized topics, followed by plenary sessions, allowing researchers to exchange last-minute information and develop a consensus viewpoint before embarking on general presentations.

From 1962 (CERN), the meetings were held every two years, alternating with the Lepton-Photon Symposium and the European International series in odd-numbered years, but continuing the Europe/USSR/USA cycle – 1964 at Dubna, 1966 at Berkeley (for the first time outside Rochester in the US), 1968 in Vienna, 1970 in Kiev, 1972 in Chicago (Fermilab), 1974 in London, and 1976 in Tbilisi. In 1978 this pattern was broken when the meeting was held in Tokyo, finally elevating the Rochester tradition to truly worldwide status.

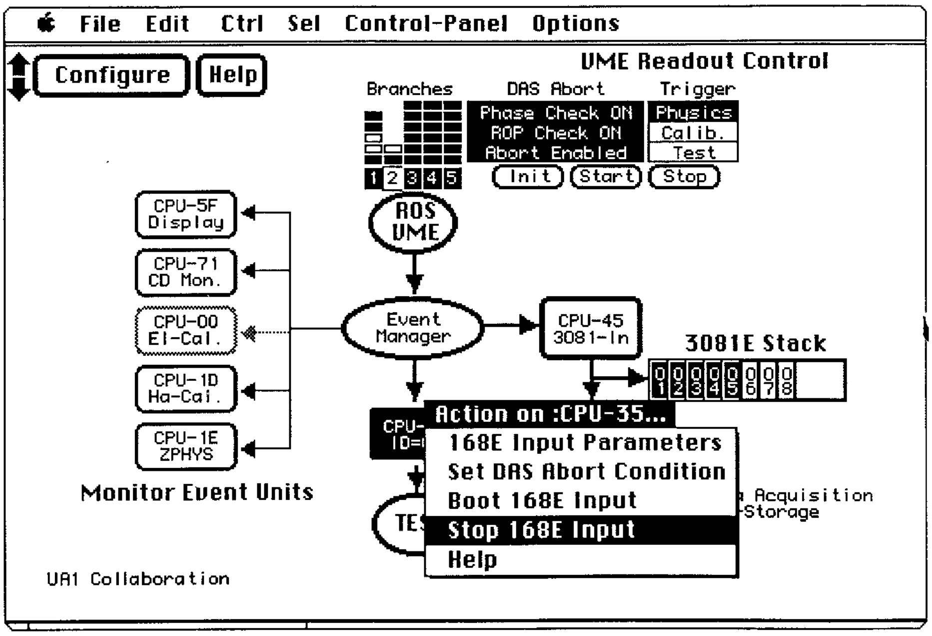
(Subsequent meetings have been held at Madison, Wisconsin, in 1980; Paris in 1982; Leipzig, German Democratic Republic, in 1984; Berkeley in 1986; and this year in Munich. The 1990 meeting is scheduled for Singapore.)

Physics pushes ahead continually, and these big international meetings reflect well the progress being made and the short-term outlook. New discoveries are being made and new ideas emerging all the time, so that participants at any major conference will be rewarded with important new information. However on an annual basis, the overall picture often changes only slowly, so that rapporteur speakers can frequently update the previous year's results with a transparent overlay.

More striking is the contrast between results at the two-year Rochester intervals, where the intricate dovetailing of major projects makes for broad new horizons. An example is the high energy frontier of electron-positron collisions. At the Munich Rochester this year, session chairman Herwig Schopper led applause for the first Rochester presentation of results from the TRISTAN electron-positron collider at the Japanese KEK Laboratory, extending now up to about 55 GeV total energy. TRISTAN results are not new, but two years previously at the Berkeley (California) Rochester, TRISTAN project leader Satoshi Ozaki reported news of machine commissioning and experiment construction. Until TRISTAN came on the air, the energy record was held by the PETRA machine at the German DESY Laboratory in Hamburg. For the 1990 Rochester meeting at Singapore, the big LEP electron-positron collider at CERN, with its 55 GeV beams (110 GeV collision energy) should have taken over the energy baton from TRISTAN and, with a year of operation under its belt, have plenty of results to report.

Macintosh in the laboratory – an approach

In experiment control by MacVEE, a hierarchy of graphical structures can be opened by the mouse to access pop-up menus and dialog boxes of interactive commands.



Since Henry Ford, the gulf between the 'bargains' available in mass-produced products and the cost of things that cannot be produced in volume has grown steadily. Since the introduction of digital integrated circuits, cost-effective systems design has been based on a philosophy of 'adapting bargain components to specific needs'. Now that popular third-generation personal computers are manufactured by mass-production methods in highly automated plant, they have become one of the 'bargain components' of today's electronic system designer. By adapting these inexpensive but powerful machines to the computing tasks they meet in laboratory instrumentation environments, engineers can make substantial savings in a variety of control, monitoring, data-acquisition and equipment-development applications.

At the Apple Computer facility in Fremont, California, one of the world's most automated factories turns out tens of thousands of Macintosh computers per month. Production on this scale permits a manufacturing and testing efficiency which cannot be approached in the production of microcomputer systems specifically for the much more limited professional instrumentation market.

Mass-produced hardware is only one aspect of the personal computer 'bargain component'. It is widely recognized that the development of efficient, reliable and well-documented software requires an investment which may substantially exceed that of designing the hardware. When this investment is spread over the vast user-base of a popular personal computer like the Macintosh, the software can be made available at a very attractive cost per system, and it receives the large exposure necessary for thorough debugging.

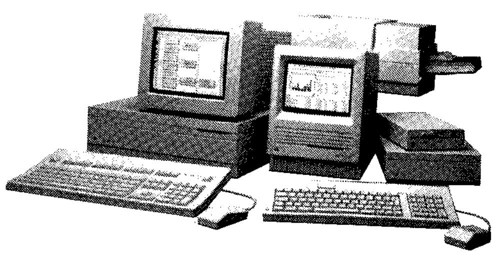
On the other hand, the introduction of international standards for professional instrumentation, such as CAMAC and VMEbus, has brought numerous benefits to on-line data-handling and computing at scientific research Laboratories such as CERN. These nonproprietary standards have made it possible to interconnect electronic equipment of varied origin, and have greatly facilitated the work of integrating large multiprocessor data-acquisition systems whose elements are developed by numerous research collaborators in dispersed institutions.

The high degree of parallelism possible in a distributed configuration of VME multiprocessors minimizes dead-time in the read-out of a large detector and allows sophisticated triggering and filtering systems to be implemented. Experience has also shown that systems based on standard instrumentation can be readily reconfigured as needs change, and enhanced as technology evolves. Apple Macintosh computers can be used as cost-effective software development workstations for such systems and their graphics-oriented user-interface has proved well-suited to control and monitoring tasks during data-taking.

MacVEE

At CERN the entire Apple Macintosh family of personal computers has been provided with compatible direct access to VMEbus and CAMAC systems, thus marrying the features of these popular mass-produced computers with the versatility of international standard instrumentation systems. The system is called MacVEE (Microcomputer Applied to the Control of VME Electronic Equipment). MacVEE has become by far the most popular personal computer instrumentation system ever used at CERN, and several hundred are currently in use at research laboratories worldwide.

● SCHNYDER



The earlier 68000-based Macintosh computers are highly integrated machines having no backplane bus structure. To implement a high-performance interface to these computers, MacVEE makes direct connection to the internal microcomputer bus. This allows selected VME and CAMAC crates to appear within the 68000 microprocessor address space, so that no special software drivers are required to access them.

The connection is made by an electronics plinth, MacPlinth, which attaches to the computer and becomes an integral part of it. MacPlinth incorporates a memory mapper accessing an external address space exceeding 100 Mbytes, in up to 8 VME crates or up to 7 VME crates and up to 8 CAMAC crates, in any mix. The mapping is controlled by a Schottky 'emmental' PROM (programmable read-only memory) which stores a 4-bit descriptor for each of the 256 64Kbyte segments of the 16 Mbyte address space of the microprocessor, and a 3-bit map selector.

The emmental PROM allocates the free addresses, and those occupied by the incomplete address decoding of Macintosh internal hardware facilities, to VMEbus cheese', while assigning 'holes' to the addresses actually referenced by the system software. Any group of segments can be mapped as common area, and code in such an area has access to resources in any of the VMEbus crates. The emmental PROM pattern can be readily changed to adapt to computers with different memory capacities, or to address changes in different versions of the System file or Macintosh hardware.

MacPlinth uses as control register the unused most-significant byte of the zero-divide exception vector. As secondary features, it generates a composite video signal for external remote monitors and accommodates up to 128 Kbytes of EPROM (erasable programmable read-only memory) for permanent library enhancements. It provides a single-level abort, internal/external reset switches, a watchdog timer and a LED array which indicates the VME crates being accessed.

Macintosh internal interrupt codes are decoded on MacPlinth, merged with external interrupt sources, and re-encoded before application to the 68000 microprocessor. MacPlinth assigns three interrupt levels to Macintosh internal auto-vectored (AV) interrupts, three levels to external user-vectored (UV) interrupts, and one non-maskable level to external AV interrupts for fail conditions and CAMAC demands. It offsets the user vector numbers to reference reserved random access memory.

VME crate access in all MacVEE systems is provided by a VMEbus master module incorporating a release-on-request (ROR) data transfer bus (DTB) requester and a 3-level VMEbus interrupt handler operating in conjunction with the processor in the Macintosh. The module includes slot-1 functions (system clock, SGL bus arbiter and global crate data-transfer time-out). It can be employed as a system controller, or as a normal DTB master in a multi-processor system.

Mac-CC

Direct access from the Macintosh family to CAMAC has been provided by Mac-CC, a memory-mapped dedicated CAMAC crate controller. It is designed in accordance with CERN recommendations for M68000-based CAMAC port controllers, and additional functions have been chosen to be as compatible as possible with VME CAMAC branch drivers and Type A2 crate controllers, as appropriate.

Each CAMAC crate occupies only 64 Kbytes of the Macintosh address space, and all Mac-CCs are accommodated within map 8. The addresses they occupy remain free for VMEbus use in maps 1 – 7. Mac-CCs allow CAMAC crates to be accessed without an intermediate VME crate and branch driver in pure CAMAC environments. In this case the CAMAC library subroutines can be accommodated in MacPlinth EPROM. The MacVEE bus uses RS485 differential transmission, and permits greater ranges than an EUR 4600 branch.

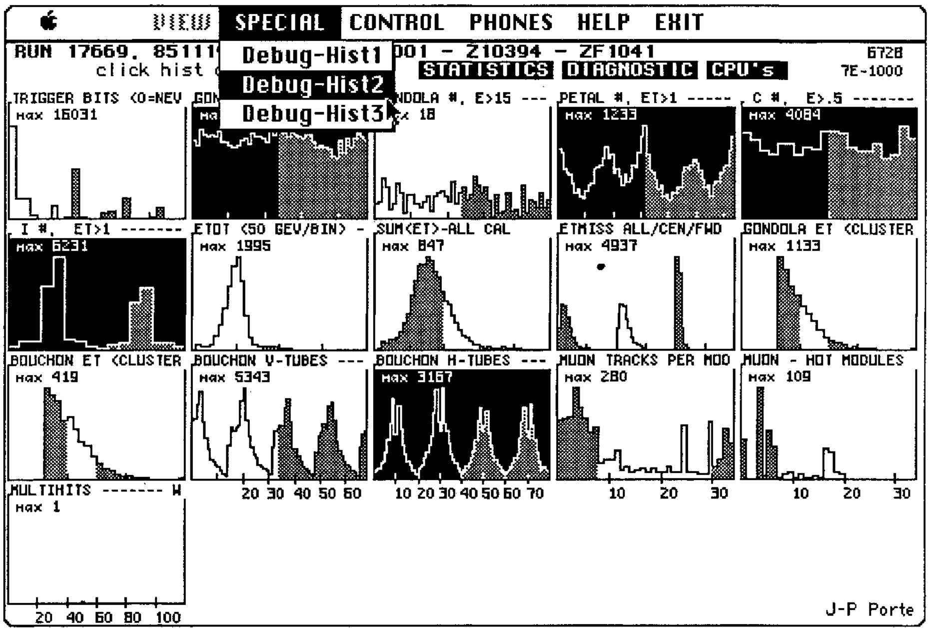
Mac-CC is equipped with an EUR 6500 auxiliary controller bus, supporting optional multiple controllers in a CAMAC crate, and is compatible with standard LAM graders. ESONE standard CAMAC subroutine libraries have been written for Fortran-77 and several Basics.

MICRON

With its floating-point coprocessor, internal hard disk, high-resolution colour graphics, enhanced toolbox ROM, optional paged MMU, networking and UNIX capability the 68020-based Macintosh II is an attractive personal computer for instrumentation applications in scientific research.

The Macintosh II has an open architecture based on the Apple NuBus, an adaption of the NuBus whose specification is currently IEEE proposed standard P1196. This specification is in turn a development of the Texas Instruments

Data acquisition monitoring by a MacVEE system for the UA1 experiment at CERN's proton-antiproton collider. The interactive display can diagnose abnormalities in the experimental statistics, and the operators are advised by Macintosh speech messages.



NuBus specification published in 1983. The original NuBus was conceived at the Massachusetts Institute of Technology, and was developed by MIT and Western Digital Corporation between 1979 and 1983.

Prior to its adoption by Apple, NuBus was little used outside AI workstations by Texas Instruments and Lisp Machine. NuBus is a time-quantized asynchronous computer backplane bus structure, with geographical addressing and multiplexed 32-bit address and data lines, which supports multiple masters with distributed arbitration. Its key design goals are claimed to be sparsity of mechanism and system architecture independence.

The Macintosh II is provided with six Apple NuBus slots. It can be interfaced to MacVEE systems by MICRON (MacVEE Interface Card Resident On NuBus), compatible with the MacVEE VMEbus master modules and Mac-CC memory-mapped CAMAC crate controllers used with the earlier 68000-based Macintoshes. MICRON allows VMEbus or CAMAC crates simply to appear within the address space of the 68020 microprocessor of the Macintosh II, so that no special software drivers are necessary to access them.

MICRON supports all data transfer operation types on the Apple NuBus, and automatically performs the required VMEbus operations so that the interface is transparent to the user. All of the address non-alignment functionality of the Macintosh II 68020 is supported through to VMEbus slaves, and restricted VMEbus resource-locking is implemented through Apple NuBus attention cycles. Data caching, which may be introduced in future 68030-based Macintosh architectures, is supported as a programmable option.

The large addressing range of the 68020-based computer allows a full 128 Mbytes of contiguous Superslot address space to be dedicated to each external system and directly accessed by the microprocessor in 32-bit mode. MICRON itself can accommodate up to 512 Kbytes of EPROM in an additional separate slot address space. The EPROM quad stores 32-bit words and can contain executable code. A small part of this EPROM contains configuration information ('declaration data') which is read by the Macintosh II slot declaration ROM manager at start-up to determine the characteristics of the hardware present in its slots.

As a result of the linear addressing scheme, even for multiple MICRON modules, no map control register or common address area is required as in 68000-based Macintosh systems. Up to 3 MICRON modules may be installed in a Macintosh II to provide direct access to 24 VMEbus crates per computer.

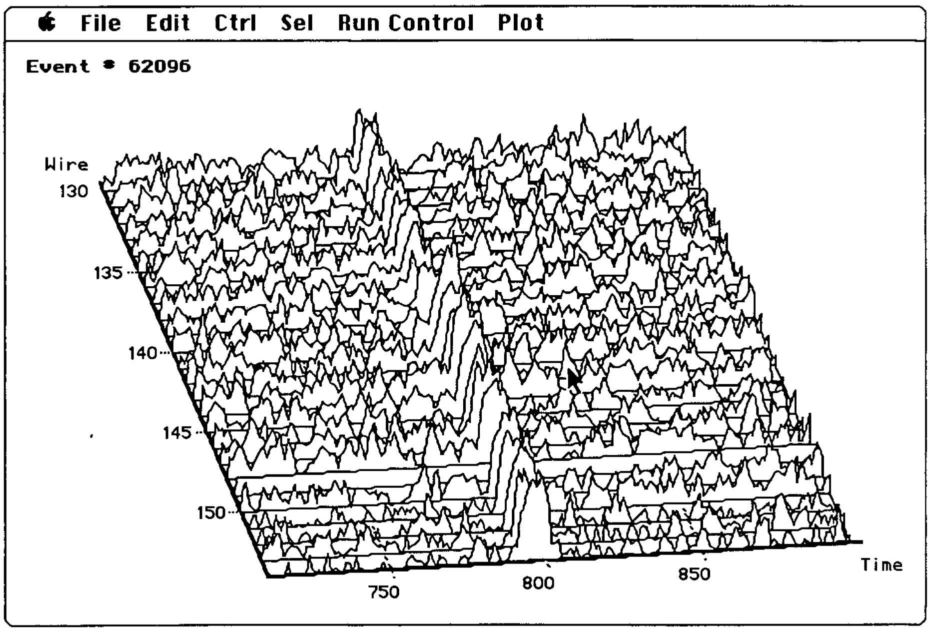
Applications

MacVEE systems are used for many different applications at CERN, at other research Laboratories, and by industry. A few examples are shown in the illustrations.

CERN's UA1 software team has created a Macintosh resident development system (MacSys) which integrates the real-time Fortran-77 compiler of Heidelberg University with an assembler, editor, linker, monitor and data-communication utilities. At UA1, multiple MacVEEs are used for the control and monitoring of the experiment, as software development workstations for a distributed hierarchy of VMEbus multiprocessors, as data-acquisition consoles with an automatic logging function, and as controllers for a farm of emulators of IBM 3081 mainframes.

Other users have created general-purpose CAMAC data-acquisition packages employed at several small experiments in which the only computers used are MacVEE sys-

In this multichannel signal display, the view geometry and other parameters can be changed using the Macintosh mouse. The flexibility of such a graphical user-interface encourages the interactive approach which proves fruitful in experimental work.



tems. In the development laboratory, MacVEEs are used for the testing of new VMEbus or CAMAC-based instrumentation. Since the software can be run entirely in the Macintosh, its integrity is safeguarded from problems with modules being debugged on the VMEbus. Access to Fastbus systems has been provided via a fast sequencer.

MacVEE tools for VMEbus and CAMAC operations have been integrated directly in the Bourne-style shell of Apple's Macintosh Programmer's Workshop (MPW), which will be used for the control and monitoring of the H1 detector at the HERA electron-proton collider being built at DESY, Hamburg. The 100 VME crates of multiprocessors required at this experiment for the read-out of over 220,000 channels of data from the 2,500-ton detector will be controlled by a dozen Macintosh II computers with MICRON.

In less than four years the Macintosh has evolved from a machine with mediocre language support to the preferred vehicle for some of the latest developments in software engineering. Several object-oriented languages are available to customize MacApp, an expandable application framework which implements the Macintosh user-interface in skeleton form. Programming laboratory applications by customizing MacApp can reduce the amount of code to be written by a factor of 4 to 5, with a corresponding decrease in the required development time.

Work is in progress to provide VMEbus access from Macintosh HyperCard, already in use at CERN for database applications. MacVEE drivers are also being developed for LabVIEW, a novel software construction environment for the Macintosh, combining dataflow concepts and traditional program-control structures with an extensive signal-processing library and a graphical-element instruction set.

The introduction of the mouse/windows/graphics environment in the research laboratory at an affordable price has spurred the development of new approaches to the control and monitoring of large experiments and new facilities for small data-acquisition and instrumentation-development systems.

The MacVEE system provides the Apple Macintosh family with an intimate connection to multi-crate VMEbus and CAMAC systems. This permits direct access to international standard laboratory instrumentation from these popular mass-produced 68000/68020-based personal computers, with their friendly graphics-oriented user interface and wide range of resident programming languages and libraries. (Further technical details are given in user manuals available from the author, while the equipment itself is now manufactured industrially in France, Germany and Italy.)

Past and Future

To conclude it is worthwhile glancing back a quarter of a century, and to try to glimpse what the future may bring over the same time span.

In 1963, CERN was operating the Ferranti Mercury computer. This was a magnificent piece of hardware whose numerous equipment cabinets occupied a very large room, but its computing power was less than today's Macintosh, about the same size as the Mercury's paper-tape reader! The CERN computer centre had also an IBM 709, the first of a long series of big number-crunchers. Once again, however, the CPU of that machine is outclassed by the present 68020 microprocessor chip.

This vividly illustrates the progress made in the last 25 years in the area of miniaturization, and there are indications that this may continue during the next 25. One of these indications comes from Japan, where the government has launched a massive R & D effort called 'Human Frontiers'.

An important aspect of this project is the development of electronic circuits based on protein molecules. Molecular electronics researchers are seeking to create molecular components to participate in their own assembly, rather like the DNA molecule. Initial applications of such self-assembling biochips might be in mass storage devices, because of the very high data density potential – some 4 orders of magnitude greater than with present optical recording techniques.

But the fabrication of a full molecular computer could be envisaged, and such a biochip could be very much smaller and very much more powerful than any silicon chip. Indeed, biochips would be so tiny that one could imagine their being embedded in the human brain, perhaps as a coprocessor, the ultimate 'personal' computer.

By Bruce Taylor, EP Division, CERN 1211 Geneva 23, Switzerland.

Parametric Current Transformer for use as beam monitor in particle accelerators

The Parametric Current Transformer (PCT) is a new instrument primarily designed to measure the intensity of a charged particle beam over a wide frequency range including DC, but its characteristics also make it the ideal instrument to measure electric currents in a conductor when galvanic isolation, up to very high voltages, is required. It features a large dynamic range, high resolution, excellent linearity and long term stability.

Eight instruments are already installed at CESR, JET, ChalkRiver, TSR and HERA. So far, best performance attained are 0.2μA resolution for 1-second integration windows, 10^7 dynamic range, in one range, and 100 kHz bandwidth.

The PCT consists of a light toroidal sensor with a large circular aperture and associated electronic circuits. The beam to be measured passes through the aperture of the sensor where the magnetic field created by the beam current is measured.

The PCT incorporates the latest available technology in respect to magnetic materials, electronics design and manufacturing techniques. Large performance improvements are obtained with the PCT as compared to those obtained with DCCTs of older design. These improvements are the results of significant technological advances in three areas:

- A new circuit concept for high resolution, high linearity and large frequency range which drastically reduces the required magnetic core's cross section.
- The use of cores made out of thin ribbons of a new amourphous magnetic alloy which features a much higher permeability at high frequency.
- A proprietary new manufacturing process to improve the characteristics and stability of these cores.

The PCT's operating principle is that of an active current transformer and a magnetic parametric amplifier in a common feedback loop.

The magnetic parametric amplifier consists of a magnetic modulator and a synchronous demodulator. A digital excitation generator drives the modulator magnetic cores in an avalanche mode with high peak currents. This reduces the effect of Barkhausen noise and improves dc zero stability in a very important way.

The demodulator uses a parametric amplifying mechanism with a very good signal to noise ratio. It virtually eliminates the contribution of noise from active amplifier circuits.

A new type of magnetic cores had to be developed because our performance objectives could not be met by any conventionnal magnetic core, neither of the older metallic crystalline tape type, nor of the chosen amorphous ribbon type.

These new cores require a sophisticated annealing treatment, both thermal and magnetic, using longitudinal and transverse fields. In addition, a very careful packaging is required to prevent mechanical stress and eddy currents.

The PCT is protected from external magnetic fields by a multilayer magnetic shield using amorphous alloys. This is important when low values of current have to be monitored.

The Parametric Current Transformer was developed by Dipl.-Ing. Klaus B. Unser of the LEP Division at CERN in the framework of a Collaboration Agreement between CERN and BERGOZ.

This agreement grants BERGOZ the right to commercialize the resulting technology.❐

bergoz

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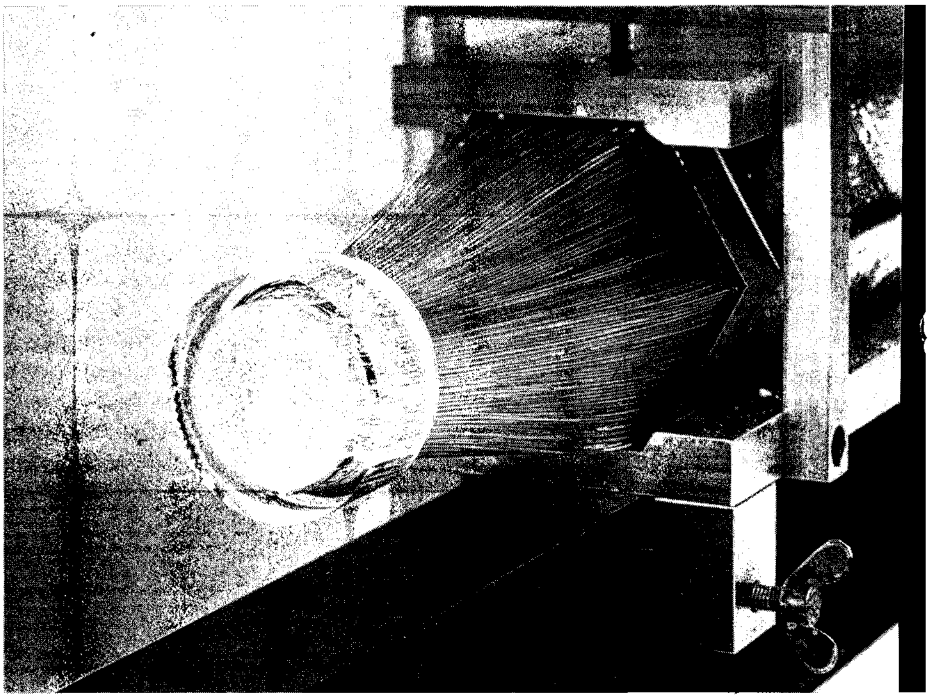
First fruits of LAA

Just one year down the line, the Italian-funded 'LAA' project at CERN under Antonino Zichichi has spawned its initial discoveries, promising a rich crop in subsequent years as the work gets into its stride.

The LAA scheme (March issue, page 16) aims to develop working prototypes of new experimental techniques to exploit proposed high energy proton supercolliders producing hundreds of millions of collisions per second. Zichichi points out the irony of today's plans for the physics of tomorrow. Even though we know in principle how to build proton machines achieving high collision rates, with each collision producing hundreds of secondary particles and with the detectors exposed to strong doses of radiation, 'no physicist on the planet would know how to perform a meaningful experiment'. On the other hand nobody yet knows how to build an electron-positron collider probing new energy frontiers, but the smaller production rates of this physics means that such a machine could be exploited by existing types of detectors.

With physicists pushing for higher event rates (luminosities of 10^{33} and above), the interval between successive proton bunches attains nanosecond or even shorter levels, calling for smart detector techniques to record and store the information from one collision before the next arrives, while being able to withstand the accompanying high levels of particle bombardment.

The LAA programme is divided into nine specialized areas – high precision tracking, calorimetry, large area devices, leading particle detection, special applications of integrated circuits, data acquisition and analysis, supercomputers and simulation studies, high magnetic fields, and high temperature superconductivity.



Prototype of the 'spaghetti' calorimeter using scintillating fibres in a lead matrix.

One technique selected to attack the goal of high precision tracking uses scintillating fibres. To achieve maximum track resolution needs very narrow fibres (less spread of measured points) with high light emission (lots of points). This initially posed problems as narrower fibres (50 microns instead of the conventional thousand microns) naturally lead to more light losses.

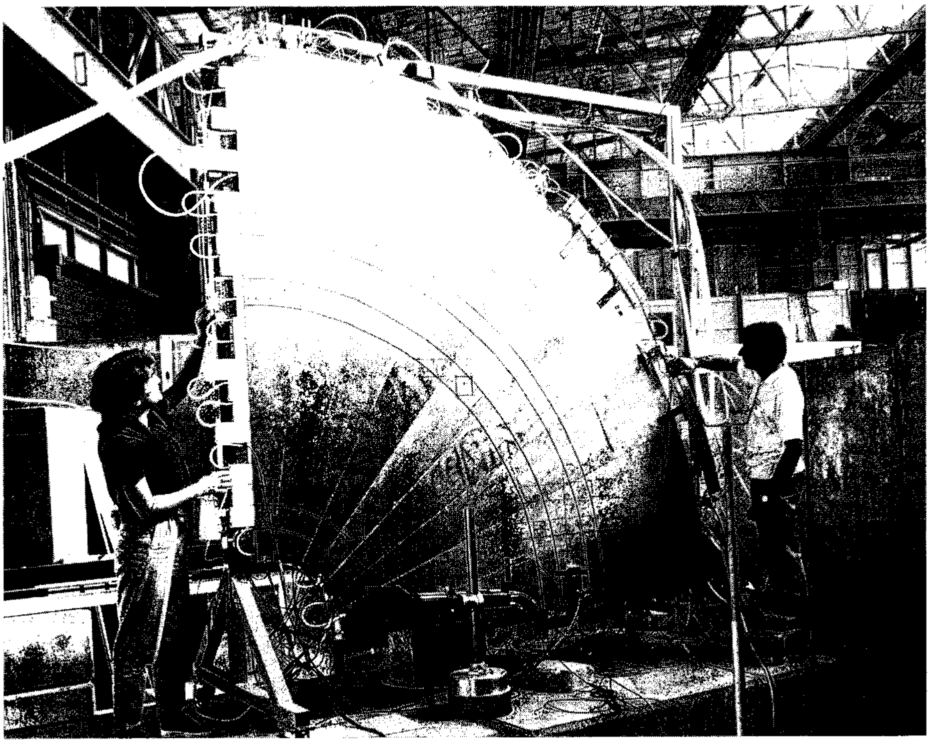
The goal was to find a new scintillator with a large separation between the absorption and emission band, avoiding reabsorbtion of the emitted light inside the fibre. After extensive tests, a suitable candidate was found – PMP - 1-phenyl-3-mesityl-2-pyrazolin, opening up a new era of 50 micron fibres.

Another LAA project aims to build a vertex detector (to track the particles immediately around the collision point) using multidrift modules. To safeguard the performance of these units in their harsh environment, ageing and radiation hardness are being studied systematically. Here stainless steel wires, with resistivities compatible with charge division measurements, look promising.

Semiconductor microstrips, based on the conventional silicon, have shown their worth in the search for short-lived particles. The LAA scheme is looking at the potential of gallium arsenide, already being exploited for a new generation of higher speed microelectronics. This new semiconductor has been found to be an order of magnitude more resistant to radiation than silicon and its other characteristics suggest increased performance and easier interfacing. Microstrip fabrication processes have been developed at the Irish National Microelectronics Research Centre, and ongoing work aims to reduce leakage currents to optimize performance.

For electromagnetic calorimetry (measurement of electromagnetic

Prototype Limited Streamer Chamber, one idea for catching forward muons over a large area.

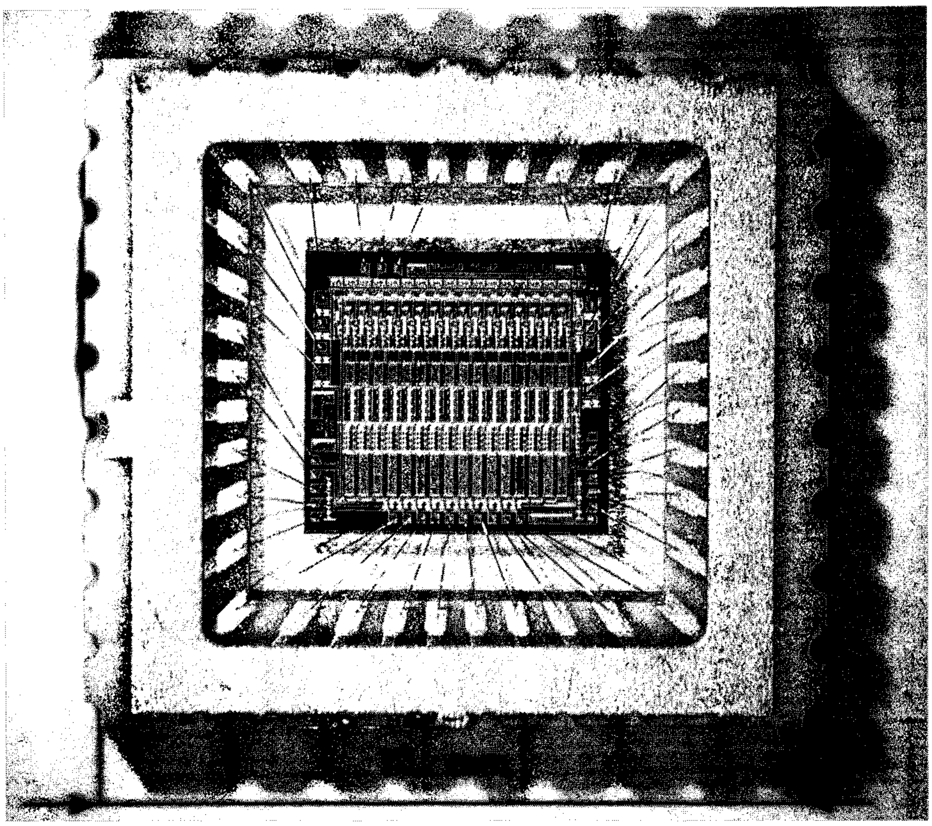


energy deposition) Georges Charpak's barium fluoride approach had been singled out as worthy of special attention. Hitherto, TMAE (tetra-di-methyl-amino-ethylene) had been used as the photosensitive gas, however the LAA work has identified ethyl ferrocene as offering better overall performance. Although less photosensitive than TMAE, its absorption spectrum is well matched to barium fluoride, while the gas is less reactive and can also be used as a liquid layer condensed on the crystals.

The other calorimetry technique under study (for measurement of both electromagnetic and hadronic energy deposition) is the high resolution 'spaghetti' instrument using scintillating fibres embedded in a lead matrix (May issue, page 27). In the search for equal calorimeter response to hadronic and electromagnetic energy, several groups have turned to uranium in the search for the ideal absorbing medium. However using efficient neutron detection, such as plastic scintillator, the binding energy released in a dense absorber such as lead can be effectively picked up. The fluctuations which dogged this approach and led to the adoption of uranium absorber are thus avoided.

Surrounding the big detectors at tomorrow's colliders will be large muon sensitive areas. Modules based on 'limited streamer tubes' have been developed, while prototypes of a new type of 'blade' chamber have been built to attack the problem of high data rates.

However no detector can be more precise than its own positioning, and one part of the LAA programme looks into high precision alignment. Using laser interferome-



Microphotograph of a centimetre-square 16-channel low noise amplifier with multiplexed output.

try, a length benchmark has been established accurate to 3.6 microns in 2 metres. The goal is to attain 5 microns in 5 metres, with similar accuracies for angles and for plate flatness.

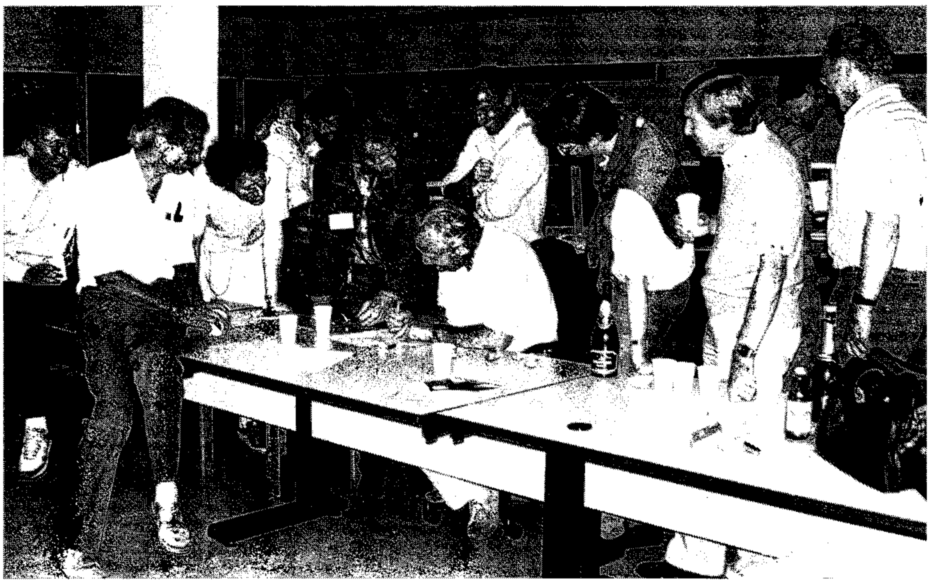
To pick up the 'leading' particles produced close to the beam direction of a high energy collider presents special problems. A solution is being worked out for a 'pot' holding the detectors, positioned to within about ten microns, and their electronics, which could be moved out of the beam in about a millisecond. Precision studies are also underway to find the optimal detector shape to minimize beam perturbations. These elements will be fashioned with 50 micron precision, ten times better than current industrial standards.

To cope with the tens of millions of electronics channels which might be needed for a full physics experiment, new VSLI microelectronics approaches are called for. As a starting point, a centimetre-square 16-channel low noise amplifier and multiplexer chip has been designed and manufacture is underway in specialist centres in Belgium. Other new chips are in the pipeline.

In the other LAA action areas, promising progress is also being made. With such a fruitful harvest after only one year's work, the rewards of the LAA investment in future years are eagerly awaited.

Around the Laboratories

DESY
HERA's welcome for electrons



HERA electron injection champagne on 20 August. Seated is Gus Voss, in charge of civil engineering and the electron ring for the 6.4 kilometre HERA electron-proton collider being built at the DESY Laboratory in Hamburg.

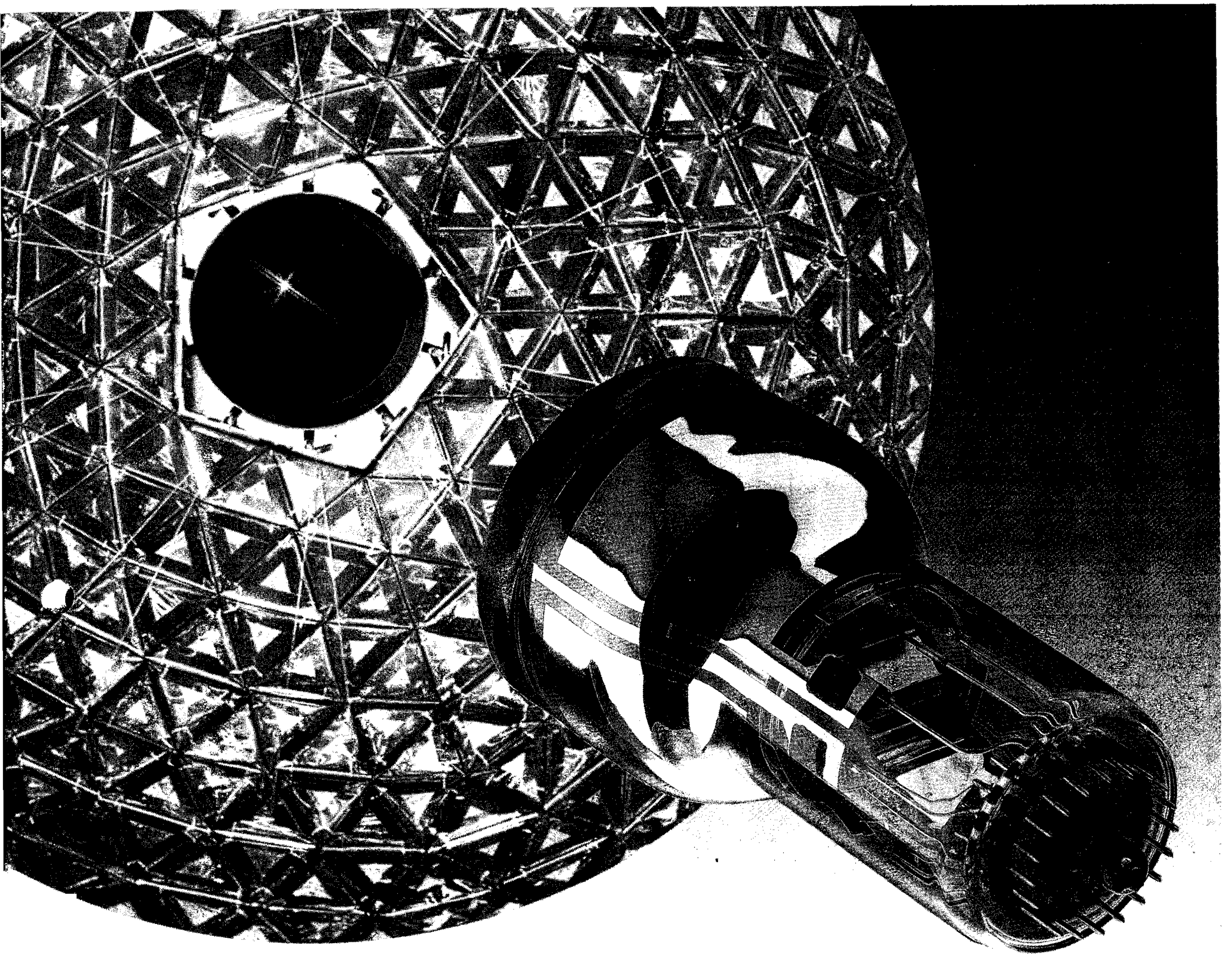
(Photo Petra Harms)

The day – Saturday 20 August, the time – 11.20 hrs. The first electron beam had circulated for several minutes in the recently completed 6.4 kilometre electron ring for the HERA electron-proton collider being built at the German DESY Laboratory in Hamburg.

A jubilant Gus Voss, leader of HERA Project Group A and in charge of HERA civil engineering and its electron ring, described the achievement. 'It was a wonderful performance by all the groups involved. Everybody worked hard, with great dedication and enthusiasm, often spending nights and weekends to finish their allotted tasks on schedule.

One week before, on 13 and 14 August, the beam transport from PETRA to HERA was ready. Single 7 GeV bunches could be transferred without losses – 100 per cent efficiency. The next two days were given over to final corrections and checking the personnel interlock system and the main magnet power circuits.

First injection into HERA was on the evening of 16th, and beam went through the first quadrant of the ring (Hall West to Hall South) without needing any corrections. Crossing the low beta section in Hall North (to squeeze the beams) needed two horizontal correction



magnets, and we reached Hall East without problems.

The remaining half turn called for power to six more correction magnets, two of them vertical. All this was done with the help of screens, one at the beginning and end of each arc. About 25 turns were made by adjusting the orbit bump at the injection magnet.

By Friday 19th we could begin to make use of the orbit monitor system, and with only a few correction coils powered, it was straightforward to accomplish 250 turns. Magnet current adjustments corresponded to machine energy increments of only 0.25 per cent. Then a small 2 kHz shift in the 500 MHz accelerating frequency enabled the injected current to be stored, and late the following morning the nominal lifetime (1/e) of a 7 GeV bunch of 3 x 10^9 electrons was two minutes. Small adjustments to the main arc quadrupole circuits allowed us to increase the lifetime to about 8 minutes.

Indicated average gas pressure during these initial injection trials was better than 10^{-8} torr. The vacuum system had been closed and the full ring evacuated only ten days before, and the final magnet put into position only one month before, on July 21. All vacuum chambers were of copper (see cover photo, September issue) instead of the aluminium used in PETRA at DESY and for the LEP electron-positron ring being built at CERN.

All HERA tests were carried out without interfering with the high energy physics programme at DESY, with the DORIS electron-positron storage ring running at 5.4 GeV, two linear accelerators, the PIA positron accumulator and the new DESY II synchrotron used for routine injection into DORIS.

The first electron beam was stored exactly one year after tunnel boring was completed. Civil engineering got underway on 15 May 1984, and the project is well within the authorized budget and the foreseen schedule.

With the HERA electron ring in such good shape, attention turns towards the superconducting proton ring, where initial octant tests are scheduled for next spring, en route to first colliding beams in October 1990.

SUPERCOLLIDER
All about money

For the proposed Superconducting Super Collider (SSC), an 84 kilometre racetrack to collide 20 TeV (20,000 GeV) proton beams, the United States Congress has approved $100 million in fiscal year 1989 for research and development, preliminary engineering and design, and site selection activities. Funds for construction or for procurement of future equipment for the SSC were not included, in keeping with Congress' general approach of no new construction starts in fiscal year 1989. Congress also proposed that construction of the SSC should not be initiated until the new US administration has had the opportunity to review the project.

The $100 million for the coming financial year represents a fourfold increase over 1988 funding, and will permit a major increase in the research and development effort, completion of site selection activities (seven sites are under consideration – March issue, page 15) and initiation of critical design activities. The big research and development push to optimize the design of the superconducting dipole magnets will continue. Other important R&D includes work on other types of magnets, other technical systems, the injector, detectors, and experimental halls and other conventional structures.

The US Department of Energy will press for construction funding for fiscal year 1990.

FERMILAB
Future polarization physics

Ask a theorist which experimental data is least understood and he's likely to respond 'spin phenomena'. Although sometimes dismissed as an inessential complication, the dependence on intrinsic angular momentum (spin) observed in a variety of strong interactions has proven to be the rocky shoal of many models. This may again be the case as spin measurements extend to higher energies and deeper into the proton (larger momentum transfer) where perturbative quark-gluon field theory is believed to be the beacon.

At the symposium on 'Future Polarization Physics at Fermilab' held in June, about one hundred experimenters and theorists met to exchange ideas on how to probe spin dependence using high energy spin-oriented (polarized) beams of protons, antiprotons, hyperons, and muons.

Results presented included the remarkable new data from the European Muon Collaboration at CERN (June issue, page 9) suggesting that the proton spin is not a simple reflection of the quark spins.

Initial operational results and future plans for the polarized proton and antiproton beams at Fermilab

were discussed along with a summary of results obtained with the accelerated polarized proton beam at Brookhaven and the new measurement of polarization in omega minus production (June issue, page 25).

Talks on technical developments included the possibility of accelerating polarized protons in the Tevatron, the use of a large polarized target in the polarized muon beam, the potential for obtaining polarized protons from the decay of charged sigmas, and some intriguing ideas for polarized electron beams and polarized helium-3 targets.

Theoretical topics included the latest on the spin distributions of quark, antiquark, and gluon constituents of nucleons, calculations of spin dependent quark structure, production dynamics, large momentum transfer effects, heavy flavour physics and polarization experiments, the origin of hyperon polarization, polarization effects in elastic scattering, and left-right asymmetry (parity violation) using longitudinally polarized beams.

J. Bjorken concluded by stressing the need for further study of the kinematical dependence of the quark spin content of the proton and neutron, and of the transfer of polarization to gluons, indicating important measurements to be made using polarized beams in a variety of sectors, and pointed out vital tests for quark-gluon field theory. Study of spin transfer to gluons appears to involve well understood double-asymmetry hard-scattering processes.

With 'oriented' particle beams continuing to provide deep insights, Bjorken invited spin enthusiasts to continue to search for innovative ways to use this unique probe of matter.

Discussing the possibilities for spin physics at Fermilab.

New polarized Tevatron beam

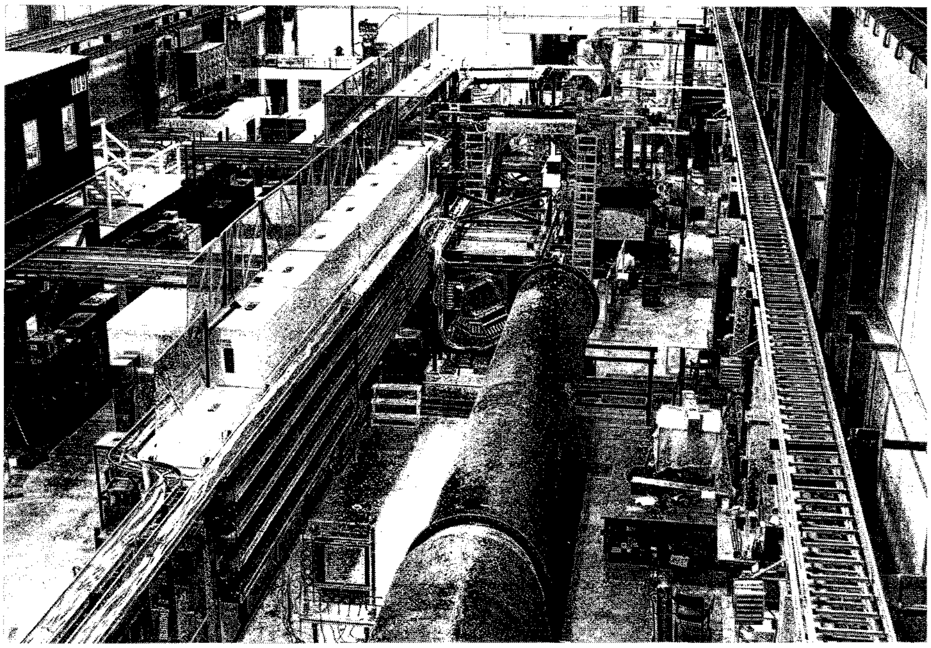
To follow up earlier indications of significant spin effects at high energy, a new polarized proton beam was commissioned during the 1987-8 fixed target run at the Tevatron.

The initial aim was to produce spin-oriented proton and antiproton beams. Among the secondary particles produced when an 800 GeV proton beam from the Tevatron hits a beryllium target are lambda hyperons and their antiparticles. Parity-violation (left-right asymmetry) in the subsequent decays (lambda to proton and negatively-charged pion, antilambda to antiproton and positively-charged pion) give a polarization of 64% as 'seen' from the lambdas – the world's highest energy polarized protons and the only polarized antiprotons.

These beams are collected at a mean momentum of 185 GeV and transported to an intermediate focus for polarization tagging. Near the final focus is a series of 12 dipole 'snake magnets' to precess the spin from horizontal to vertical or longitudinal and reverse the polarization direction (to reduce systematic errors).

In the latest run the proton and antiproton yields were studied and the beam polarization measured. Protons and antiprotons tagged to correspond to polarizations above 35% were selected, and threshold Cherenkov counters rejected pions. 10^{12} protons per 20 second spill gave 8 x 10^6 protons and 4 x 10^5 antiprotons, in good agreement with design calculations. An increase in primary intensity to 4 x10^{12} protons per 20 second spill is expected for the next data-taking period.

Polarization physics detector at Fermilab, looking upstream toward the polarized experimental target. The pipe in the foreground is the threshold Cherenkov counter. The experiment is getting ready for physics during the next fixed-target running period.



Two polarimeters were used to measure the spin level and to confirm the validity of the tag. One relies on the Primakoff effect where the analyzing power for production by an incoming high energy proton of a proton and a pion by the electromagnetic field of a heavy nucleus can be related to the known low energy polarized target asymmetry (up to 90% in some kinematic regions) in photoproduction of the corresponding pion-nucleon system. Using a 3-mm lead target, lead-glass calorimeter and a magnetic spectrometer, it was possible to see the Primakoff events in the appropriate kinematic region and check the beam polarizations at 40 ± 12%, in agreement with the design calculations.

The other polarimeter exploits the interference in elastic scattering between the nuclear non-flip and the electromagnetic spin-flip processes, about 5% at an optimum value of momentum transfer. Preliminary analysis using this technique also indicates the beam polarization to be consistent with design expectations.

In the next fixed-target period the experiment will get to grips with polarization phenomena, aiming to study production of a range of particles using an unpolarized hydrogen target, while the difference in production rates of spin states in proton-proton and antiproton-proton scattering will also be examined using a polarized proton target.

An initial result indicative of the future physics is a significant asymmetry (10 ± 2%) in neutral pion production at large momentum fraction (x). Antiprotons show an average asymmetry of −26 ± 19%. This process will be used as a beam polarization monitor. The collaborating institutions are Argonne, Fermilab, Kyoto, Kyoto Sangyo, Iowa, Kyoto University of Education, KEK, LAPP-Annecy, Los Alamos, Northwestern, Rice, Saclay, Serpukhov, Texas, Udine, UOE Kyushu, Hiroshima and INFN Trieste.

BEIJING
New ring accelerates first beams

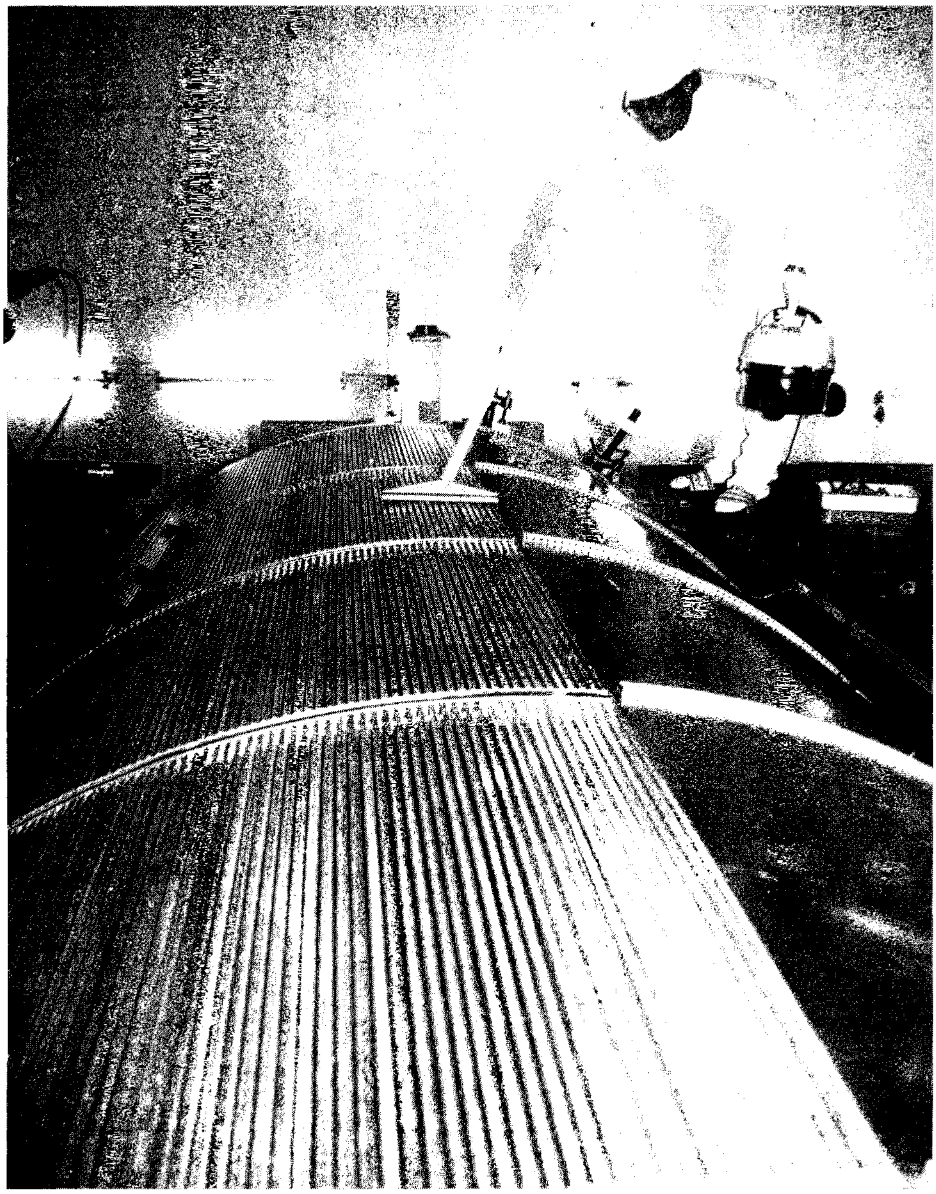
Following injection of the first beams into the new 240 metre storage ring of the BEPC Beijing Electron-Positron Collider (March issue, page 4), now electrons and positrons have been stacked and the beam energy in the ring ramped up for the first time.

Fed by a linac, BEPC is designed to take electrons and positrons to between 2.2 and 2.8 GeV. After a four-month shutdown for installation and testing of a radiofrequency cavity, BEPC commissioning resumed in May with electron beams from the linac stable to within one per cent. Initial stacking trials encountered puzzling difficulties but nevertheless Zhou Guang-zhao, President of the Academia Sinica, opening the international symposium on synchrotron radiation applications in Beijing on 26 May, was able to report 'we have heard the first cry of the "baby"'.

After some fumbling in the dark, the troubles were eventually traced to mislabelled power supplies for two quadrupoles, and the ring started behaving according to plan.

After a ten-day break to prepare the injection linac for positron working, commissioning resumed in July, and a 4 mA positron beam made a prompt appearance. Electron currents attained 50 mA without closed orbit correction. For a stored 15 mA beam the lifetime was about one hour, and with minimal losses energy was ramped from 1.1 to 1.6 GeV, and from an injection configuration to a colliding one. Multibunch injection for synchrotron radiation operation was also tested.

Careful work went into the shower counter of the BES detector for the BEPC electron-positron collider now being commissioned in Beijing.



The goal now is to get electrons and positrons colliding by the end of October.

Meanwhile in June the 40 ton, 3.8 metre wide barrel shower counter of the BES detector was moved into the BEPC electron-positron collision area. Having earned the local name 'big eggs' in view of its weight and fragility, this unit is designed to measure deposited electromagnetic energy (calorimetry), using a barrel and endcaps with a gas/lead sandwich structure involving a total of more than 12,000 electronics readout channels. 24 layers of 560 self-quenching streamer tubes will pick up the showers produced in the lead plates.

To provide the required 23 different cylindrical lead radii, cylindrical panel sandwiches of aluminium-clad lead were built, ten panels per layer. The barrel spool was made in the Shanghai aircraft factory, and the stringing of the 13440 wires in the 24 layers was completed last year.

The main drift chamber of the BES detector with its 48 modules of scintillating time-of-flight counters was moved to the experimental hall on 14 July.

DARMSTADT
New accelerator takes shape

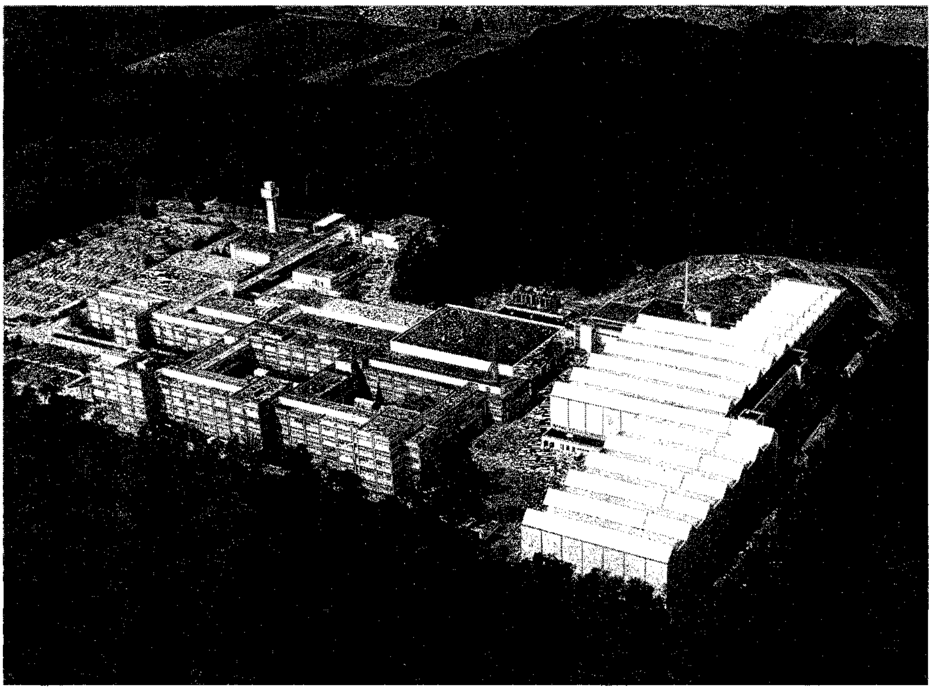
Work is now nearing completion for the major extension of the Darmstadt Heavy Ion Laboratory (Gesellschaft für Schwerionenforschung, GSI) authorized in May 1985. It includes the modification of the existing Unilac heavy ion linac, the construction of a 200 metre synchrotron ring (SIS), a heavy ion storage ring (ESR) half the circumference of the SIS, and five new experimental setups for ion beams in the range 20 MeV-2 GeV per nucleon. New buildings house both the new rings and their associated target stations.

To allow continuous use of the Unilac in the traditional low energy domain between a few and 20 MeV/n, and to use it also at fixed energy as the new SIS injector, 50 poststripper quadrupoles and steering magnets were replaced by pulsable devices. This work is now complete, and next year a second front-end linac will be available, allowing independent ion selection.

After completion of the ring tunnel this spring, the 24 dipoles and 12 triplet groups were installed and the dipole power supplies tested at full load, fed from the grid. The test included typical magnet ramp

Aerial view of the Darmstadt heavy ion Laboratory (Gesellschaft für Schwerionenforschung, GSI). Right are the buildings of the new accelerator complex, with (top) the earth hill covering the new SIS synchrotron. The central new hall will house the ESR experimental storage ring, while fixed target experiments will be set up in the lower hall.

(Photo Regierungs-Präsidium Darmstadt, 773/88)



shapes and sinusoidal waveforms between 1 and 20 Hz. The new control system, designed for freely programmable magnet current functions, performed well.

Installation of other synchrotron components is progressing and one vacuum sector has been closed and baked out, attaining its 10^{-11} mbar design pressure without any difficulties. The 120 metre Unilac-SIS transfer line will be tested by the end of the year. Beam injection tests are scheduled next April, following by a six-month running-in phase, and the operations software brought to a level where the Unilac operators can take over the SIS for production runs.

One of the first experiments will be the fragmentation of primary uranium beams and the subsequent isolation of exotic nuclei in a 70-metre fragment separator downstream.

Late next year the ESR storage ring will come into operation, providing 'cooled' beams of completely stripped uranium ions and accumulated nuclear fragments for both internal and external target experiments. The ring components are being procured and field measurement of the large aperture dipoles is imminent. The stochastic precooling system relies on hardware developed at CERN for work with antiprotons, while the complementary 340 kV electron cooler for installation in one of the 9.5 metre ESR straight sections is undergoing initial tests.

The high resolution projectile fragment separator between SIS and ESR will lead to a diversified physics programme including the study of heavy nuclear fragmentation, the structure of heavy neutron-rich nuclei, and nuclear fusion. The finely tuned beams in and from ESR will provide a powerful new tool for precision nuclear studies, and perhaps produce highly ordered 'crystalline beams'. Other GSI goals include a full angular coverage detector to look at the behaviour of hot dense nuclear matter, continuing the exploratory work at the Berkeley Bevalac.

This radical expansion of the GSI complex has been pushed by Christoph Schmelzer, who celebrates his 80th birthday in November. At CERN in the 1950s, he designed the radiofrequency and beam control system for the CERN PS protor synchrotron. As founder and first director of GSI he foresaw the extension of GSI's accelerators to include a rapid cycling, large acceptance synchrotron with sufficient energy to strip all electrons from uranium atoms.

BROOKHAVEN
The chips are down

Some of the most densely packed working computer chips in the world have been made at the US National Synchrotron Light Source (NSLS) at Brookhaven using X-ray lithography.

Using the NSLS vacuum ultraviolet ring, IBM researchers have made test chips with only 0.5 micron spacing between components – several times denser than standard mass-produced chips. These smaller spacings (line widths) open the door to memory chips holding more than 64 Megabits, and faster, more economical computers.

Production-line chips have 1.2 micron line widths, and although other experiments have produced spacings below 0.5 microns, fabrication of full chips on this scale is not straightforward. The IBM work at Brookhaven used four gold-plated boron-doped silicon masks patterned by electron-beam litho-

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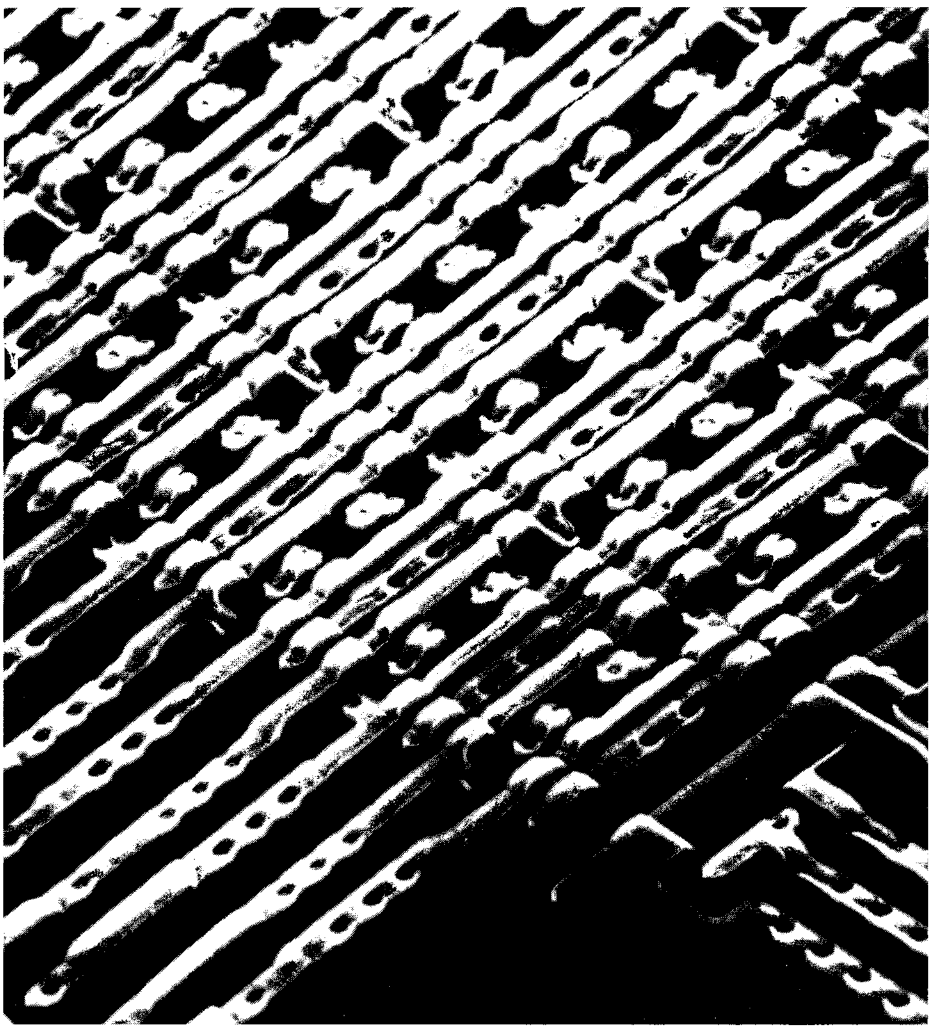
graphy at IBM's own research centre.

X-rays, with their shorter wavelength, overcome the resolution problems inherent in optical lithography, and the development of new compact X-ray synchrotron light sources for chip manufacture is being pushed hard in several countries. Brookhaven has been hosen as the site for a new superconducting X-ray lithography source in a $207 million US Department of Defense programme (story next month).

Meanwhile a compact X-ray source is being designed and built for IBM by Oxford Instruments in the UK, and a $20 million contract has been awarded to Maxwell-Brobeck of San Diego for a source for the Center for Advanced Microstructures and Devices at Louisiana State University, Baton Rouge.

The face of chips to come. Electron microscope picture of a chip developed by IBM using an X-ray beam from the US National Synchrotron Light Source at Brookhaven. Metal lines, less than a micron across, connect to transistors (seen as small dark circles) half a micron in diameter.



People and things

On people

Helen Edwards, Head of Fermilab's Accelerator Division, has been awarded a prestigious MacArthur Fellowship by the Chicago-based MacArthur Foundation in recognition of her key role in the construction and commissioning of Fermilab's Tevatron ring.

The 1988 Dirac Medals of the International Centre for Theoretical Physics (ICTP), Trieste, Italy, have been awarded to Efim Samoilovich Fradkin of the Lebedev Physical Institute, Moscow, and to David Gross of Princeton.

Fradkin's award marks his many fruitful contributions to quantum field theory and statistics: functional methods, basic results applicable to a range of field theories, the quantization of relativistic systems, etc., which have gone on to play a vital role in modern theories of fields, strings and membranes.

Gross, with F. Wilczek, and independently H. Politzer and G. 't Hooft, discovered 'asymptotic freedom' in the theory of quark fields, thus explaining how quarks can be both locked inside nucleons under ordinary conditions and be tractable as free particles in field theory calculations. Later he went on to contribute to the invention of the 'heterotic' string, opening the door to new understanding in the quest to unify the basic forces of physics through the theory of strings.

John Peoples becomes Deputy Director of Fermilab. Research Division Head from 1975-80, Peoples went on in 1981 to become Head of Fermilab's Antiproton Source Project.

ASSISTANT PROFESSOR

The Department of Physics, University of Wisconsin-Madison anticipates one or more tenure track positions at the assistant professor level to begin Fall, 1989 or later. Applicants should provide evidence of teaching skills and ability to carry out an independent research program. Preference will be given to nuclear physics experimentalists, to condensed matter theorists, and to particle theorists/phenomenologists. Apply to

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by November 15, 1988. The University of Wisconsin is an equal opportunity/affirmative action employer and especially encourages women and minorities to apply.

UNIVERSITY OF CALIFORNIA, RIVERSIDE

FACULTY POSITION IN EXPERIMENTAL RELATIVISTIC HEAVY ION COLLISIONS

The Department of physics at the University of California, Riverside expects to make a faculty appointment in the area of Experimental Relativistic Heavy Ion Collisions during the 1988-89 academic year.

Individuals with a background in experimental nuclear/particle physics are invited to apply. The level of appointment will be that of Assistant Professor (tenure-track) or, for an exceptionally qualified individual with an established record in research, an Associate Professor (tenure) appointment can be considered.

The individual appointed will be expected to join the ongoing Riverside research program in relativistic heavy ion collisions.

Please send a resume and request that at least three letters of reference be sent to

Chair, Search Committee,
Experimental Relativistic Heavy ion Collisions
Department of Physics
University of California
Riverside, CA 92521

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MAINTENANCE ENGINEER

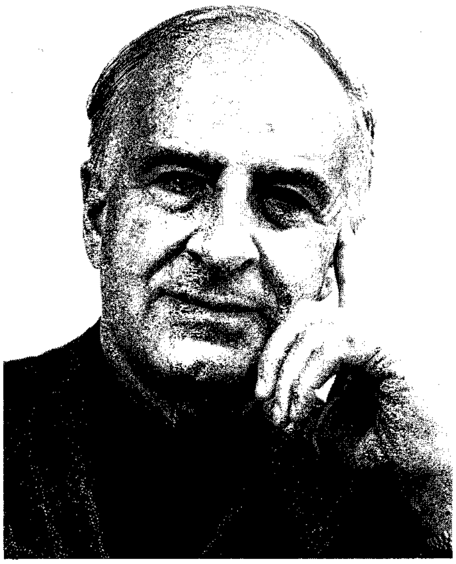
I am seeking qualified candidates for a full-time permanent position as Maintenance Engineer. Equipments to be maintained are Fastbus and VME modules and power supplies manufactured by Dr. B.Struck & Co. of Hamburg and installed at CERN. The candidates are expected to be experienced electronics engineers, familiar with Fastbus and/or VME. Fluency in English is essential. Knowledge of French and German are an advantage. The successful candidate is expected to relocate to the French "Pays de Gex" nearby CERN after an initial training period in Hamburg.

Letters of application, including a CV, must be sent to:

Julien BERGOZ
CROZET
01170 Gex, France

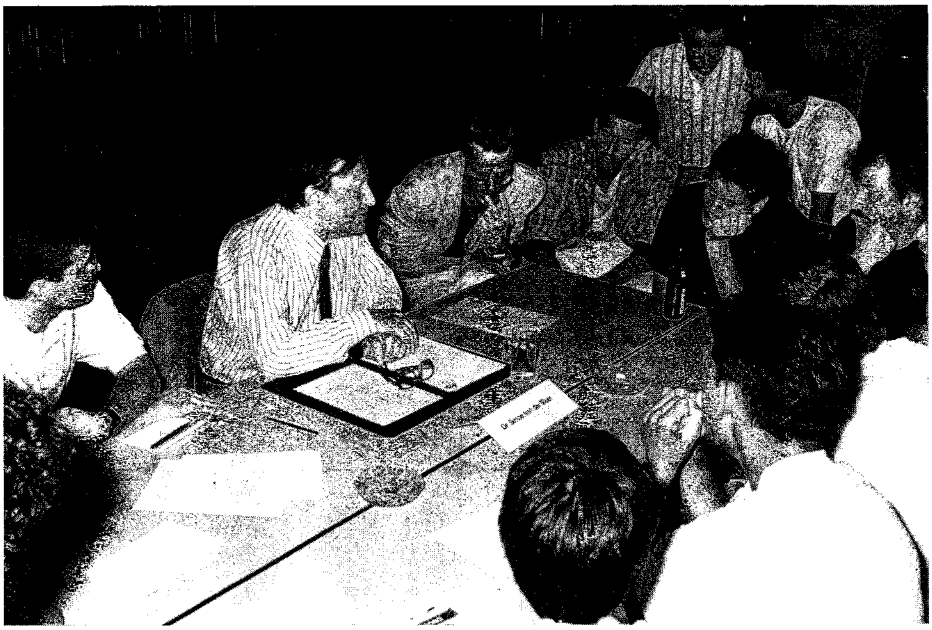
Candidates of any nationality may apply

Bruno Pontecorvo – 75 this year



Simon van der Meer of CERN at this year's gathering of Nobel laureates in the Bavarian island town of Lindau, Lake Constance. Initiated in 1951 by Count Lennart Bernadotte, these annual Lindau Nobel meetings alternate between chemistry, medicine and physics.

(Photo Jacobs, Lindau)



In August scientists at the Joint Institute for Nuclear Research, Dubna, USSR, celebrated the 75th birthday of Bruno Pontecorvo, Department Head in the Laboratory of Nuclear Problems. From the illustrious Fermi school, Pontecorvo has spent most of his scientific career in the USSR. Well known for his fundamental contributions to neutrino physics, where among other things he has played pioneer roles in the quest to measure the neutrino's mass and in the idea of neutrino oscillations, he has also furthered our understanding of the muon and other particles.

Larry Trueman is Brookhaven's new Associate Director for High Energy and Nuclear Physics, replacing Robert K. Adair, who returns to Yale. In addition to his particle physics accomplishments Adair is official physicist to the US National Baseball League.

August marked the 75th birthday of Wolfgang Paul, President of the Humboldt Foundation. He has spent most of his career at Bonn, where he was a prime mover behind the electron synchrotron, the first European accelerator to use the alternating gradient technique. At CERN from 1964-7, he was first joint Head of the Nuclear Physics Division, then Director of Physics I Department. He was Chairman of the Scientific Policy Committee from 1975-77.

1982 Nobel Prizewinner and Director of Cornell Theory Center Kenneth Wilson is leaving Cornell for Ohio State.

Stanford's CERN Courier correspondent Michael Riordan is the 1988 winner of the American Institute of Physics Science Writing Award in Physics and Astronomy for his book 'The Hunting of the Quark'.

TRIUMF reorganization

With $11 million in pre-construction funds for the proposed KAON Factory, a major reorganization took place at the Canadian TRIUMF laboratory in Vancouver on September 1. Alan Astbury heads the new project, organized in three divisions: Accelerator (M.K. Craddock), Science (P. Kitching), and Technical (E.W. Blackmore). The existing programme is reduced to four divisions, with the old Science and Experimental Facilities Divisions amalgamated under J.-M. Poutissou, who also acts as Associate Director.

Luis Alvarez

Berkeley pioneer and 1968 Nobel laureate Luis Alvarez, who developed Donald Glaser's bubble chamber idea into a versatile physics tool, died on 1 September, aged 77.

▲ One of the recipients of the US National Medal of Science this year from President Reagan (September issue, page 32) was Jack Steinberger, head of the Aleph experiment now being assembled at CERN's LEP electron-positron collider (see page 4).

(White House Photo)

▼ At a meeting at CERN on 1 September of the Delegation Suisse-Romande of the Weizmann Institute of Science, Rehovot, Israel, former French Minister and President of the European Parliament Simone Veil (left), as Honorary President of the Pasteur-Weizmann Council, presented CERN Director General Herwig Schopper with the Israeli Institute's Gold Medal. Right is J.-J. Brunschwig, the Delegation's chairman.

Heinz Pagels

As announced briefly in our previous issue, Heinz Pagels, particle physicist, gifted popularizer of science and executive director of the New York Academy of Sciences, died in a climbing accident in July with his former student at Rockefeller University Seth Lloyd, while they were attending the Aspen Physics Centre.

While Pagels was at Rockefeller, his book 'The Cosmic Code' was published in 1982, and he turned to fresh pastures at the New York Academy of Sciences. Subsequent books were 'Perfect Symmetry' (1985) and more recently 'The Dreams of Reason – The Computer and the Rise of the Sciences of Complexity'. He was also President of the International League for Human Rights.

Meetings

The 1989 European Physical Society High Energy Physics Conference will be held in Madrid from 6-13 September. These biennial EPS conferences (Bari 1985, Uppsala 1987) have parallel sessions with individual contributions and plenary sessions with review talks. Further information from F. Barreiro, Dept. Fisica Teorica, C-XI, Univ. Autonoma de Madrid, Cantoblanco, 28049 Madrid, Spain.

A EULIMA (European Light Ion Medical Accelerator) workshop on the potential value of light ion beam therapy will be held at the Centre Anthoine-Lacassagne, Nice, France, from 3-5 November. Further information from the EULIMA Workshop Secretariat, Bibliothè-

que, Centre Anthoine-Lacassagne, 36 Voie Romaine, 06054 Nice Cedex, phone 93 81 71 33, ext. 2514, telex 470 344 F, bitnet farley at froni51.

The 1989 International Symposium on Heavy Quark Physics will be held from 13-17 June at Cornell. Attendance will be limited – further information from Mary Wright, Newman Laboratory, Cornell University, Ithaca, New York 14853, USA, bitnet symp89 at crnlns.

An advanced accelerator physics course, organized jointly by the CERN Accelerator School and Uppsala University, Sweden, and placing special emphasis on the problems of small rings, will be held from 18-29 September in Uppsala. Further information from Mrs. S. Wartburg, CERN Accelerator School, LEP Division, 1211 Geneva 23, Switzerland, bitnet casuppa at cernvm.

Books

'Physics at LEAR with Low Energy Antiprotons', the proceedings of the Workshop on CERN's LEAR Low Energy Antiproton Ring held in Villars last year (December 1987 issue, page 11), are published by Harwood Academic Publishers.

The UK Institute of Physics Publishing Division has recently published (under its Adam Hilger imprint) – Interactions and Structures in Nuclei, edited by R.J.Blin-Stoyle and W.D.Hamilton, as the proceedings of a conference held last year to celebrate the 65th birthday of Sir Denys Wilkinson (November 1987 issue, page 35).

'Collider Physics – Current Status and Future Prospects', edited by J.E. Brau and R.S. Panvini, is the title of the proceedings of the meeting held at Vanderbilt University, Nashville, Tennessee in October 1987 (December 1987 issue, page 5), published by World Scientific, Singapore.

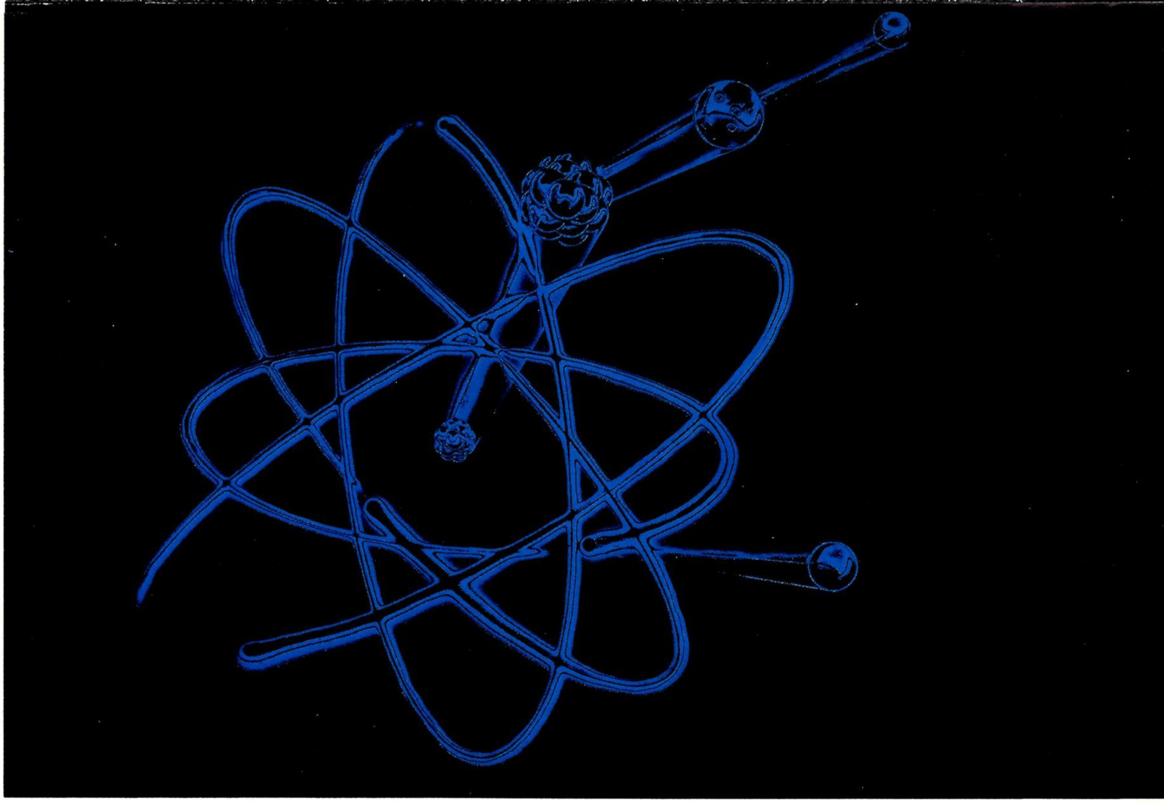
'Charm Physics', edited by Ming-Han Ye and Tao Huang, is the title of the proceedings of the China Centre of Advanced Science and Technology (CCAST, World Laboratory) Symposium/Workshop held at the Institute of High Energy Physics, Beijing, in June 1987, published by Gordon and Breach.

Particle physics and industry

The November issue of the CERN Courier will feature the growing involvement of particle physics with front line technology. Stories from CERN and other leading research centres will illustrate the close links with industry which are an integral part of many new research projects.

Viktor Weisskopf 80

As a tribute to Viktor Weisskopf on his 80th birthday, an international colloquium 'Science, Culture and Peace' was organized by CERN and by the 'Ettore Majorana' Centre for Scientific Culture, Erice, Sicily, at CERN on 19 and 20 September. Paying tribute to the great man, distinguished speakers – colleagues, friends, admirers, former students – from all over the world had plenty of material to cover.



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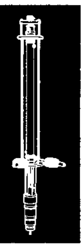

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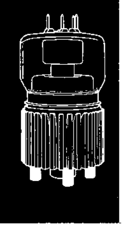

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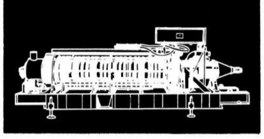

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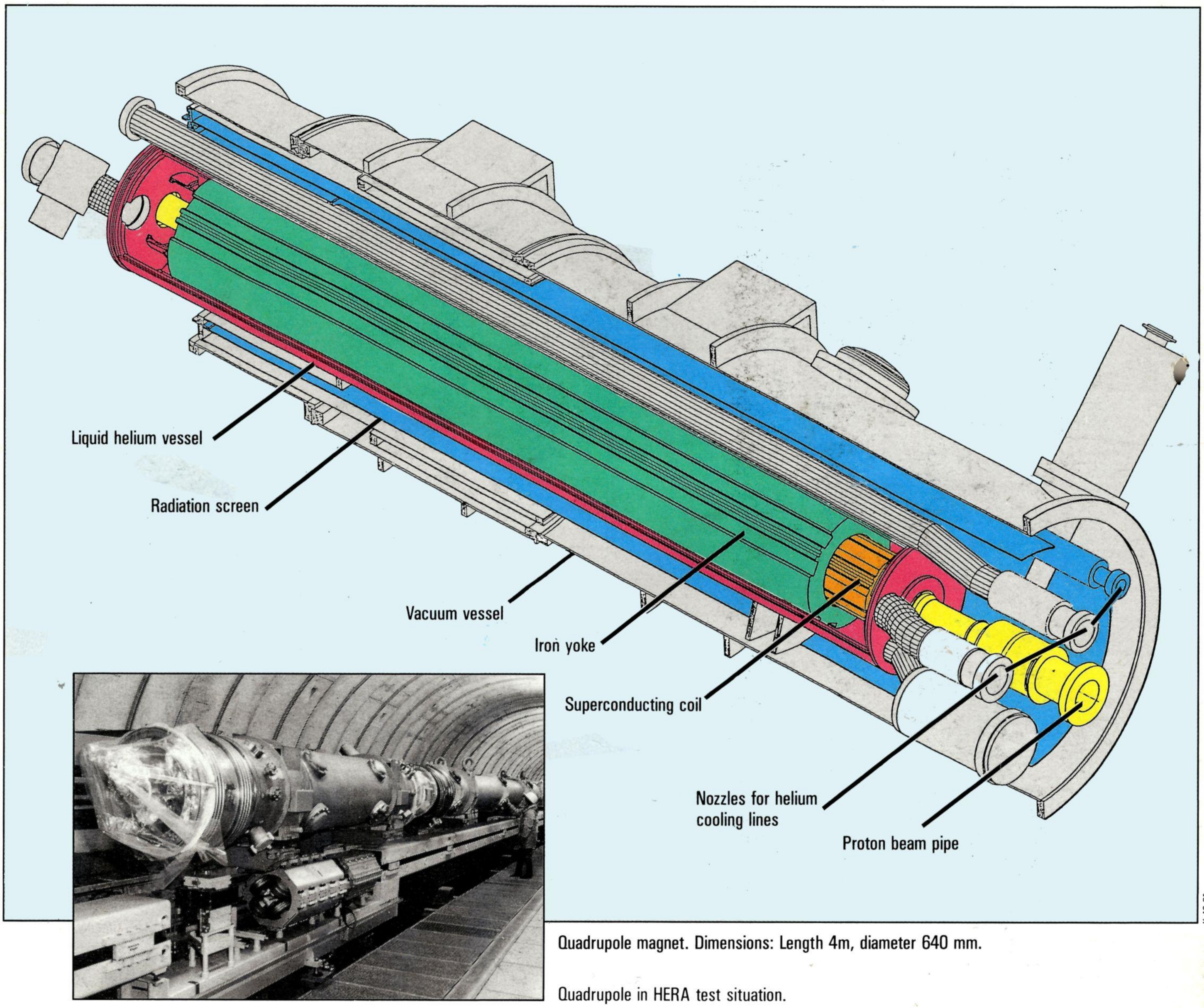
Superconducting quadrupoles for the HERA storage ring



Quadrupole magnet. Dimensions: Length 4m, diameter 640 mm.

Quadrupole in HERA test situation.

HERA is a proton/electron storage ring which will provide scientists at DESY with new opportunities for research into matter.

The first industrially fabricated superconducting magnet for the HERA storage ring was supplied by NOELL to DESY in December 1987.

The order comprises a total of 120 superconducting quadrupole magnets of various lengths and types. The three pre-production magnets have already been successfully tested at a temperature of 4 °K.

NOELL fabricates and assembles magnets and cryostats including the helium and vacuum vessels. The helium vessel has to be of particularly high quality, as it must achieve an extremely low leakage rate.

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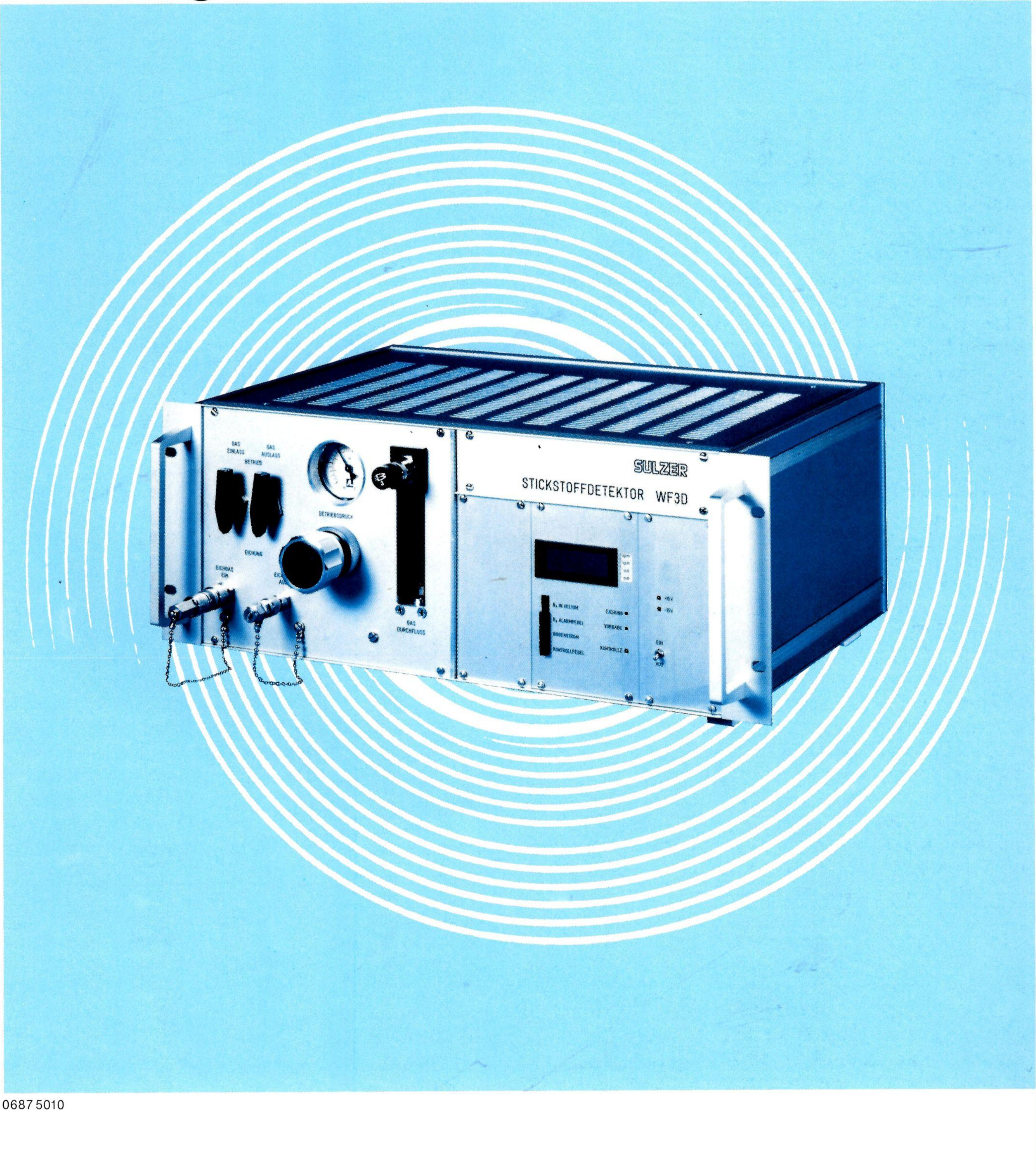
Cryogenics

Nitrogen in Helium Detector



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- No carrier gas required
- High degree of stability
- Inlet pressure 1–20 bar gauge

1. Application

Measurement of nitrogen (N_2) in helium (He).

2. Measurement principle

Optical emission spectroscopy. Excitation of the gas is obtained by use of an electrical discharge between two metal electrodes. Analytical line emission is selected by an interference filter. Measurement of radiation is by means of an Si photo-diode.

3. Data of gas to be measured

- Inlet pressure 1–20 bar gauge
- Outlet pressure 0.05–0.3 bar gauge
- Rate of gas flow 0.03 Nm^3/h

4. Range and accuracy of measurement

- Standard range of measurement 2–50 vpm N_2
- Indicated range 0–199.9 vpm N_2
- Resolving power 0.1 vpm
- Reproducibility $\pm$0.1 vpm, typical value for range 2–30 vpm
- Accuracy without re-calibration $\pm$2 vpm

5. Indication, outputs

- 3½ position liquid crystal indication (LCD)
- Analogue signal 4 to 20 mA, corresponding to a measurement of 0 to 50 vpm N_2. Resistance load min. 250 Ω, max. 500 Ω
- Relais output adjustable over the whole measurement range. Maximum loading:
  DC 30 W, 50 V, 1 A
  AC 250 VA, 250 V, 1 A

6. Dimensions, weight

Equipment size suitable for fitting into 19″ rack to IEC 297/DIN 41494.

- Height 177.8 mm (4 units ≙ 7″)
- Casing depth 305 mm
- Weight ca. 13 kg

7. Power supply, ambient temperature

- Supply voltage 220 V, 50/60 Hz
- Permissible variation in supply voltage $\pm$10%
- Power input max. 150 W
- Permissible ambient temperature range 0 to 40 °C

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